CANADIAN ELECTRONICS ENGINEERING

DECEMBER 1961
A Maclean-Hunter publication
five dollars a year

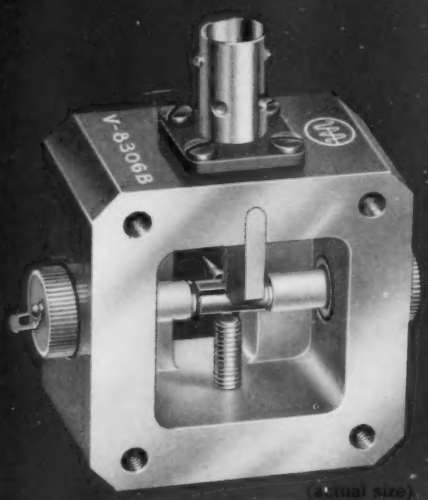
DEC 26 1961

Information theory paves way to communications developments

Tests show how snow and leaves in antennas cause signal loss

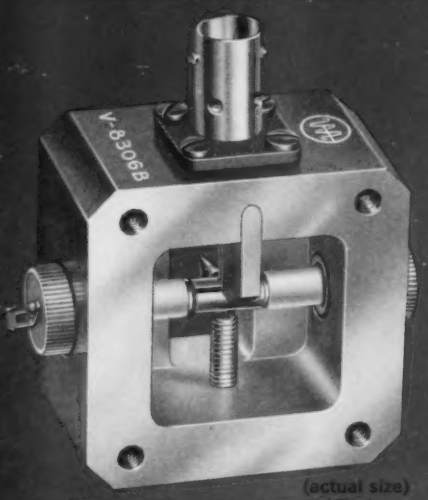
How CFRB-FM built its stereophonic broadcasting system

Featuring: Recent developments in communications



(actual size)

MIXER



(actual size)

MODULATOR

V-8306B

Carrier Frequency, 7.6-8.6 kMc
Carrier Power, 300 mW max.
Modulating Signal Frequency, 0-100 Mc/s
Carrier Rejection, 20 db minimum
Conversion Efficiency, 8 db nominal

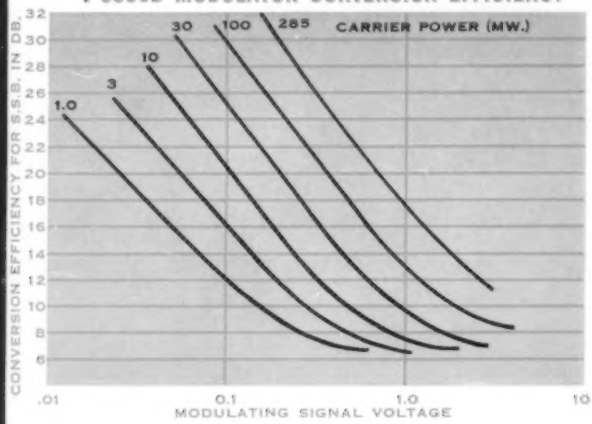
THE MIXER WITH THE DUAL PERSONALITY

Here's important design news! Varian Orthomode® balanced mixers are equally effective as modulators.

When any of Varian's broad line of mixers is operated as a modulator—with microwave power applied to a waveguide port and modulating signal voltage to the IF connector—conversion loss approaches the minimum theoretical level.

Varian mixer-modulators are more compact than TWT's, more efficient than ferrite devices at high modulating signal frequencies. Unusually small size and weight provide the answer to difficult packaging problems. Inexpensive. Designed for straight-line hookup, simplifying waveguide arrangements. Available in X, S, and C bands.

V-8306B MODULATOR CONVERSION EFFICIENCY



Technical data on this exciting new use for orthomode balanced mixers available on request.

Klystrons • Travelling Wave Tubes • Backward Wave Oscillators • Magnetrons • Gas Switching Tubes • Microwave System Components • Microwave Equipment • High Vacuum Products • Strip Chart Recorders • Research and Development Services.

VARIAN associates of Canada Ltd.

GEORGETOWN, ONTARIO

BOMAC LABORATORIES, INC.
VARIAN ASSOCIATES, CALIFORNIA
S-F-D LABORATORIES, INC.
SEMICON ASSOCIATES, INC.
SEMICON OF CALIFORNIA, INC.
VARIAN A.G. (SWITZERLAND)

Representative: R-O-R Associates, Toronto, Ottawa and Montreal

For further information mark No. 62 on Readers' Service Card

CANADIAN ELECTRONICS ENGINEERING

Volume five number 12 December 1961

Information theory paves way to new developments in communications

The subject of information theory is introduced by drawing attention to recent areas of specialization. Its association with communication theory, modulation theory and cybernetics is considered, followed by an analysis of the generalized communication system.

Douglas A. Carruthers, P.Eng. graduated in 1955 from U of T with a BSc in electrical engineering. He joined the Bell Telephone Co. of Canada's radio systems engineering group and was transferred to a wire transmission group in 1958. This was followed by 18 months of special training at Bell Telephone Laboratories. He is now supervising engineer, data communication systems, with the customer services engineering group.

35

How CFRB-FM built its stereo system

Anticipating the advent of stereophonic broadcasting in Canada, radio station CFRB began planning and practising in 1959. When authorization was granted on September 1, 1961, CFRB-FM was ready for the new medium. This account of their equipment and experiences should be of use to other stations planning on entering the field.

G. Clive Eastwood, P.Eng. graduated from U of T in electrical engineering and has been with radio station CFRB in Toronto since 1938. He is now chief engineer of CFRB, CFRB-FM and CFRX, and director of engineering of CJAD, Montreal. Mr. Eastwood is chairman of the Broadcast Committee of CRTPB and is regarded as one of Canada's foremost engineering experts on stereo broadcasting. He is a member of the IRE.

41

These specifications govern stereo broadcasting in Canada

Here are the main features of the two relevant specifications issued by the Radio Regulations Division of DOT on stereophonic FM broadcasting and subsidiary communication multiplex operation.

43

Tests show how snow, ice and leaves in microwave antennas cause signal loss

Accumulation of foreign matter in horizontally-mounted parabolic antennas produces serious signal loss in microwave relay systems. This article presents the results of tests with ice, snow and leaves. Analysis of the results and a mathematical study show the cause of the loss.

Frank R. Willis received his Bachelor of Science degree in electrical engineering from Michigan State University in 1958. He then joined Andrew Corporation in Chicago, where he is employed as a Product Development Engineer in the Antenna Design Group. This article is based on a paper originally presented at the 1961 IRE Canadian Electronics Conference.

45

Electronics industry pledges support for Ottawa research plan

Special report on a meeting between John L. Orr, Director of Industrial Research, and the Electronics Division of EIA of Canada, at which plans for electronics research were discussed.

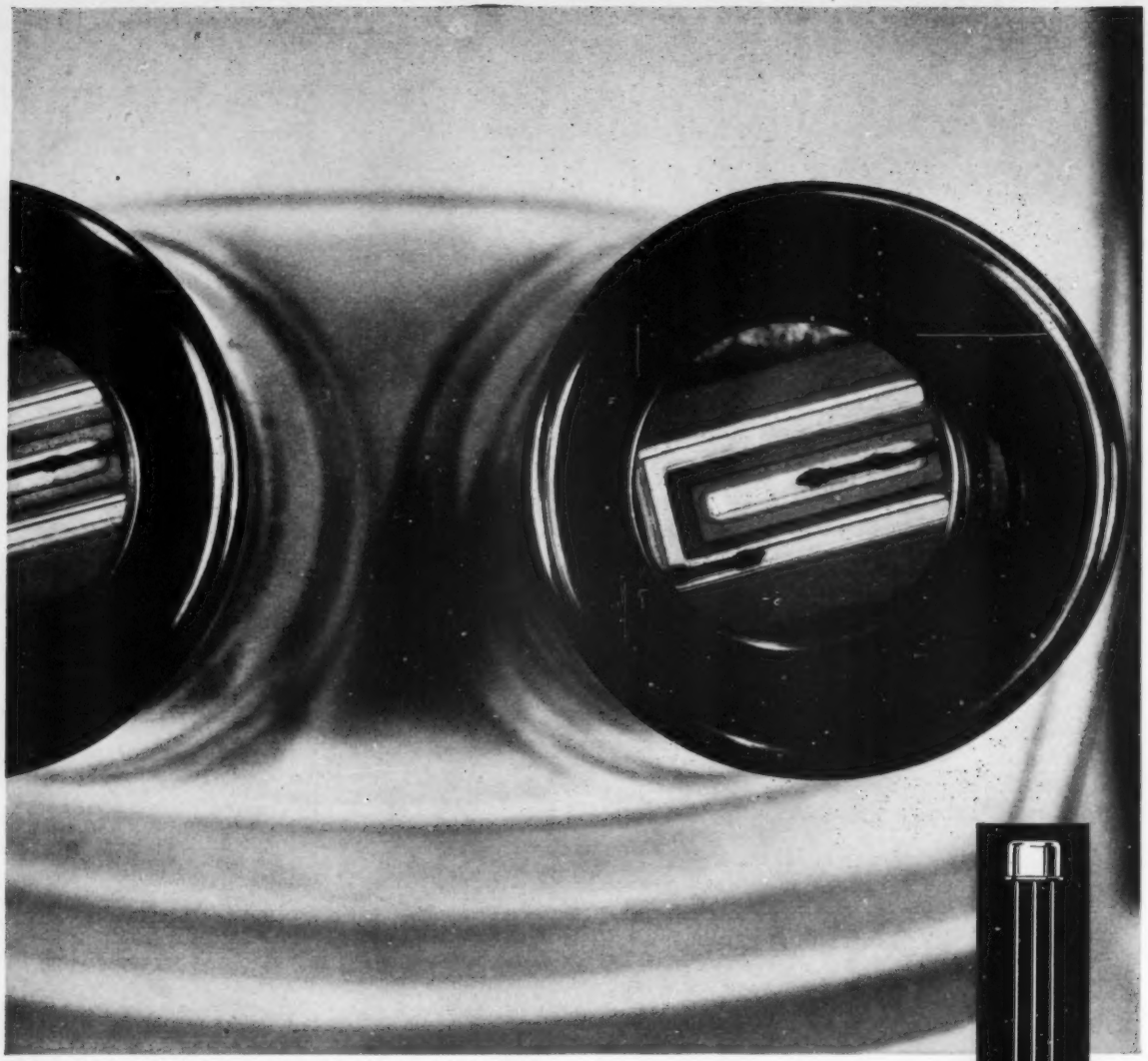
48

New facility will help shape future of communications in Canada

Northern Electric Company, aware of the challenges that lie ahead, has opened a research centre at Crystal Bay, two miles west of Ottawa. Two buildings have been completed, with provision for two more in the future. Present staff is 200 scientists, technicians and others.

49

CONTENTS — continued on page 3



Intricate "machining" of junctions is inspected under powerful microscopes

even miniaturization remains MANAGEABLE...

"*Precision in small things*" best sums up the General Instrument technique—however small the device, however demanding the ultimate application.

Precision and *miniaturization* may seem contradictory aims since the human eye falls somewhat short as a manufacturing tool, below certain size limitations.

At General Instrument *Semiconductor*, where the most intricate "machining" processes are carried out as routine, this is solved by working under a magnification of 600X . . . thus representing each millimeter as nearly two feet!

Only by doing this can the pure gold welds of silicon and germanium wafers to hermetic leads be perfected without risk of microscopic burrs or discrepancies in formation.

Such micro-manipulation typifies our approach to the business of producing semiconductors. In the Canadian semiconductor facility at WATERLOO there is no limit to the care and attention that go into building highly reliable products.

GI CANADA

GENERAL INSTRUMENT SEMICONDUCTOR
DIVISION OF GENERAL INSTRUMENT
F. W. SICKLES OF CANADA LIMITED
151 Weber Street South, Waterloo, Ontario

GERMANIUM — SILICON — SELENIUM
TRANSISTORS • DIODES • RECTIFIERS
"ZENERS" • THERMOELECTRICS
SEMICONDUCTOR CIRCUIT MODULES

For further information mark No. 36 on Readers' Service Card

CONTENTS — continued from page 1

Solid state devices change economics of microwave systems

Introduction of solid state devices has changed the economic structure of microwave installations. This article shows how the relative cost of fixed plant and services has gone down and the cost of electronic elements has risen, then describes Motorola's solid state equipment.

John E. Raftis, a graduate in business administration and electronics engineering, started his technical career in 1941 at Research Enterprises Ltd. After service with the RCN he spent eight years with the Communications Engineering Division of Ontario Hydro, then worked for Philips for five years. He joined Canadian Motorola Electronics in 1958 to manage the newly created Microwave and Industrial Products Division.

52

Index of editorial features Canadian Electronics Engineering — Volume 5 — 1961 **60**

Departments

News highlights	5	Controls and instrumentation	64
Ottawa report	7	IRE News	65
People in the industry	9	CAMESA News	70
Reports from the industry	11	Defense contracts	70
What's new in view	56	Round-up: coming events	78
New products	58	Advertisers' index	80

CANADIAN ELECTRONICS ENGINEERING

staff

Harold Price, BSC, SEN. MEM. I.R.E., P.ENG., *editor*

Ian R. Dutton, BASC, MEM. I.R.E., P.ENG., *associate editor*

Gordon Duffy, *Montreal editor*

Richard J. Gwyn, *Ottawa editor*

Raymond A. Tulloch, *Manitoba editor*

Robert A. Metcalfe *British Columbia editor*

Frank Davies, *editorial art director*

Robert E. Swan, *advertising representative*

Kenneth E. Winchcombe, *Eastern advertising representative*

Murray R. Mark, *West Coast manager*

G. M. James, *U. K. representative*

W. A. Weir, *advertising art director*

Mary Ann Sapiano, *advertising production*

John F. Foy, *circulation manager*

R. G. Scott, *research manager*

J. W. Sargent *sales promotion manager*

C. A. King, *manager*

George W. Gilmour, *publisher, industrial publications*

J. L. Craig, *vice-president and director, business publications division*

a Maclean-Hunter publication

Authorized as second class mail by the Post Office Department, Ottawa, and for payment of postage in cash.

Printed and published by Maclean-Hunter Publishing Company Limited, 481 University Avenue, Toronto 2, Canada. Tel.: 362-5311.

Offices at 1242 Peel Street, Montreal. UN. 6-9841; Room 505, Fuller Bldg., 75 Albert St., Ottawa. CE. 6-0895; Room 1004, The Burrard Bldg., 1030 West Georgia Street, Vancouver 5, B.C. MU. 3-8254; Maclean-Hunter Limited, 30 Old Burlington St., London W.1. England.

Floyd S. Chalmers, President; Donald F. Hunter, Vice-President and Managing Director.

Publishers of The Financial Post, Canadian Advertising, Canadian Aviation, Canadian Controls & Instrumentation, Canadian Electronics Engineering, Canadian Hotel Review, Canadian Industrial Photography, Canadian Machinery, Canadian Nuclear Technology, Canadian Packaging, Canadian Printer and Publisher, Canadian Shipping, Design Engineering, Electrical Contractor, Food in Canada, Heating and Plumbing Engineer, Heavy Construction News, Materials Handling in Canada, Modern Power, Modern Purchasing, National Builder, Office Equipment and Methods, Plant Administration, Progressive Plastics.

Other services: The Financial Post Corporation Service; Canadian Press Clipping Service; Commercial Printing Division.

Subscription rates: Canada $5.00 per year, two years $9.00, three years $13.00. Single copy price $1.00. U. S. A., United Kingdom, $10.00 per year; all other countries $20.00 per year.

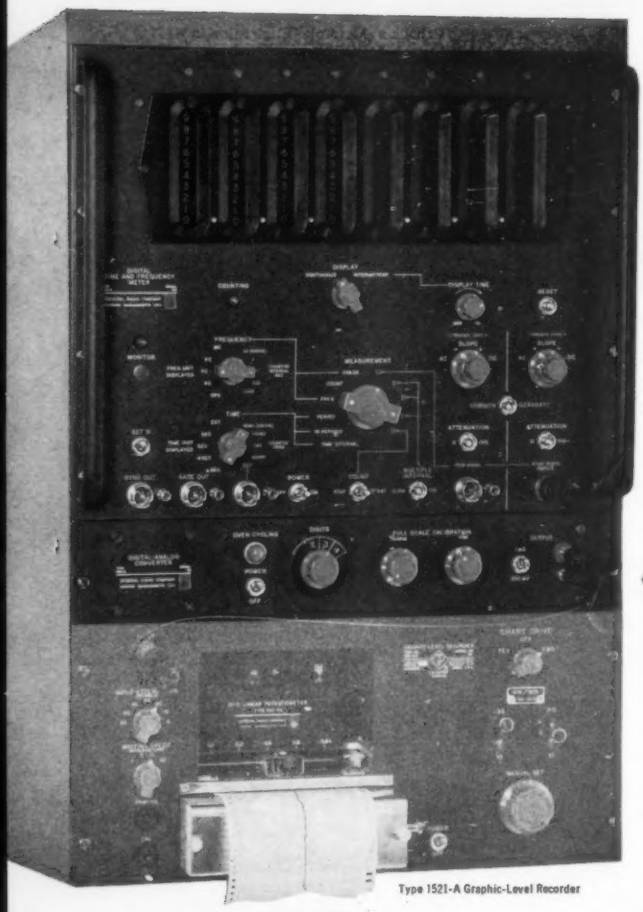
Indexed in Engineering Index.

Member Canadian Circulations Audit Board, Inc. CCAB

Member Business Newspapers Association. BNA

Invited to illustrate one of our features on communications developments, cover artist Otto Van Eersel chose Clive Eastwood's article on FM stereo broadcasting.

The Counter with a Memory *also writes*



Type 1521-A Graphic-Level Recorder

The G-R Counter's unique storage circuits vastly simplify graphic analog recording. To decode the Counter's output to a d-c analog voltage you simply add G-R's all electronic Digital-to-Analog Converter.

For those desiring tabulated digital data, a Data Printer is available which connects directly to the Counter (no modifications or adaptor kits required).

1130-A Digital Time and Frequency Meter

Measurement Ranges:
Frequency: dc to 10 Mc
Period: 10μsec to 10^7 sec
Time Interval: 1μsec to 10^7 sec
Also measures 10 periods, frequency ratios, phase shifts, pulse characteristics, and counts random events.

Display:
8 digits intermittent; 4 digits continuous readout (previous count displayed continuously during counting interval; changes to new value when count is completed).

Sensitivity: 0.25v rms

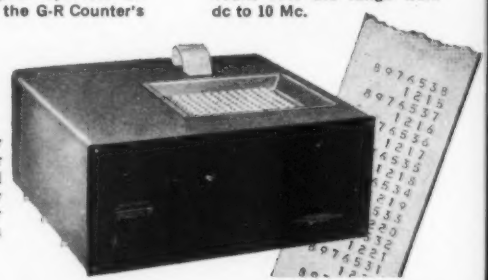
Accuracy: ±1 count ± time-base stability. A variety of plug-in time-base generators are available with short-term stabilities ranging from 1 part in 10^8/min to 1 part in 10^9/min.

Price: From $2,585 to $2,950 depending on time-base generator desired.

1134-A Digital-to-Analog Converter $595

Will drive any standard 1 ma.(or 100 mv) recorder

- High Accuracy —
  Linearity: ±0.05% of full scale
  Stability: ±0.02% for ±15% line voltage variations; ±0.03% for ambient temperature changes over the range from 0 to 50 C.
- All Electronic — No mechanical data printer required to convert counter output to steady analog signal. Operates directly from the G-R Counter's internal storage system.
- Either 1 ma or 100 mv output. Connects readily to most d-c strip-chart recorders.
- Records first 3, last 3, or last 2 digits of the G-R Counter's 4-digit continuous display which may be set to read any four consecutive digits of count over the range from dc to 10 Mc.



1132-A DATA PRINTER, $1450, for unattended measurements

Provides permanent printed records on adding machine tape. The printer has a 12-column register capacity, eight of which are used to print counter output. The remaining four columns can be used to display additional data such as time from a digital clock. Printing rate is adjustable from one print every twenty seconds to three prints per second. A keyboard and print-command bar allow numbers to be typed manually between automatic prints. An output for driving an IBM summary punch is available as a special option.

Write for Complete Information

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS

Canadian Engineering Office and Service Facilities in TORONTO
99 Floral Parkway, Toronto 15, Ontario
Arthur Kingsnorth • Richard J. Provan
Tel: CHerry 6-2171

For further information mark No. 37 on Readers' Service Card

NEWS HIGHLIGHTS

Direct telecommunications between Canada and Argentina now exist.

Dr. Arturo Frondizi, President of Argentina, opened direct telecommunications between Canada and Argentina last month. He transmitted a telex message from Ottawa to Buenos Aires to inaugurate the service. The facilities, established by Canadian Overseas Telecommunication Corp. provides telex, telegraph and telephone service.

EIA members report rising TV sales; radio sales are expected to climb now that import quotas have been filled.

Members of the Receiver Division of the Electronic Industries Association of Canada have reported that sales at the end of October were 1.7% ahead of the same period last year. Improved economic conditions have stimulated trading-in old models.

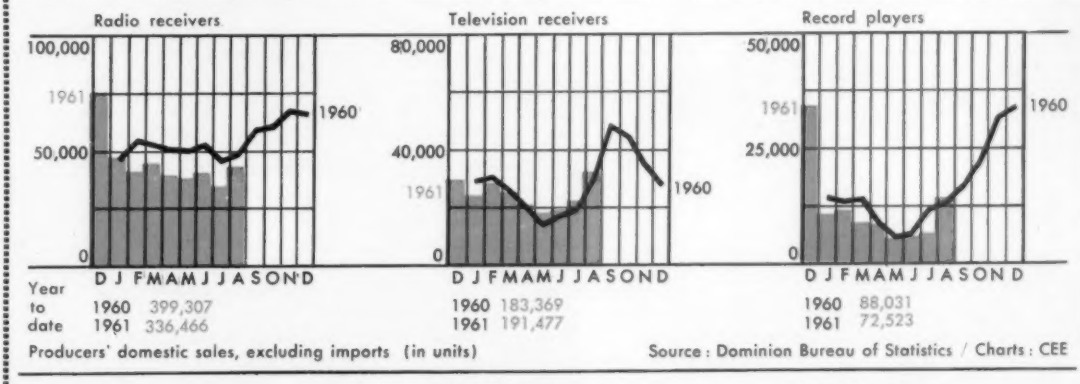
Radio receiver sales for the same period were down 3.6%, largely due to imports which took 68.4% of the market in the first six months. The export of tube radios by Japan to Canada has been suspended as of Nov. 26, and the 1961 quota of transistorized radios from the same source was reached on Oct. 27. Sales of Canadian produced radios should rise for the remainder of the year.

Stereophonic and monophonic high fidelity radio photograph combinations gained 42.6% for the first 10 months of 1961. The industry expects the demand to continue.

A new Canadian standard has been set for sound systems in public buildings. A proposed standard for power transformers in radio equipment is being submitted for approval.

Electronic Industries Association of Canada standard CRS-20 for installation of sound systems in public,

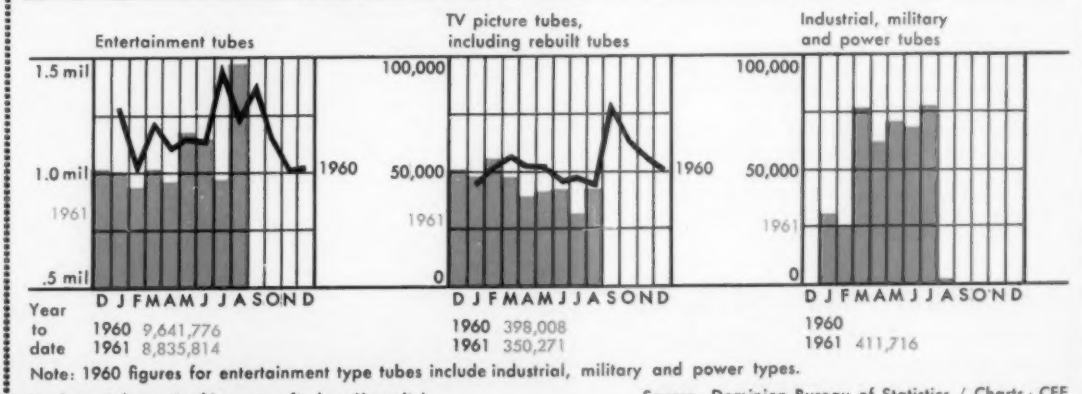
(Continued on page 7)



Year to date	Radio receivers	Television receivers	Record players
1960	399,307	183,369	88,031
1961	336,466	191,477	72,523

Producers' domestic sales, excluding imports (in units)

Source: Dominion Bureau of Statistics / Charts: CEE



Year to date	Entertainment tubes	TV picture tubes, including rebuilt tubes	Industrial, military and power tubes
1960	9,641,776	398,008	
1961	8,835,814	350,271	411,716

Note: 1960 figures for entertainment type tubes include industrial, military and power types.

Producers' domestic shipments of tubes (in units)

Source: Dominion Bureau of Statistics / Charts: CEE

124 completely hermetically sealed Microwave Mixer and Video Diodes

ALL ARE DIRECTLY SUBSTITUTABLE FOR CONVENTIONAL DIODES TO ASSURE UNPRECEDENTED SYSTEMS RELIABILITY.

Microwave Associates has answered your need for truly hermetically-sealed diodes. For the first time, both fixed-base and reversible polarity types have CERAMIC-TO-METAL SOLDER SEALS plus SOLDER END SEALS.

Whatever the requirement – from 1 Mc to 18 kMc, a new diode is available to replace the present diode — extra high burnout types for high signal level circuits and behind radar duplexers—new low-noise types for doppler receivers.

The MA-458F, for example, replacing the 1N23E, has a calculated overall noise figure of 7.0 db — the lowest noise figure available for high reliability applications.

These diodes (and coaxial case and subminiature glass packaged diodes) assure military and commercial applications the reliability essential to uninterrupted service for exceptional time spans. They perform to 150°C and meet the applicable environmental requirements of MIL-S-19500.

MICROWAVE ASSOCIATES, INC
SEMICONDUCTOR DIVISION
BURLINGTON, MASSACHUSETTS • WESTERN UNION FAX
TWX: BURLINGTON, MASS. 942 • BROWNING 2-3000
E. G. Lomas, 227 Laurier Avenue West,
Ottawa, Ontario, Canada. Tel. CEntral 2-8504

SILICON MIXER DIODES
1 Mc — 4,000 Mc
CARTRIDGE CASE

Improved Types
For low noise superheterodyne mixer performance
• Replace 1N21 series

Fixed Base Types		Matched Pair		Reversible Polarity Types	Calculated Overall Noise Figure N.F. 1.5db IF (db)	Burnout Rating (ergs)
Forward Polarity	Reversed Polarity	Forward Pair	Forward & Reversed			
MA-449B	MA-449BR	MA-449BM	MA-449BMR	MA-459B	10.3	5.0
MA-449C	MA-449CR	MA-449CM	MA-449CMR	MA-459C	8.3	5.0
MA-449D	MA-449DR	MA-449DM	MA-449DMR	MA-459D	7.3	5.0
MA-449E	MA-449ER	MA-449EM	MA-449EMR	1N21WE	7.0	5.0
MA-449F	MA-449FR	MA-449FM	MA-449FMR	MA-459F	6.0	5.0

Higher Burnout Types
For use in pulse radars or other receivers exposed to high RF radiation fields.
• Interchangeable with 1N21 series

MA-4127	MA-4127R	MA-4127M	MA-4127MR	MA-4132	8.3	10

Lower Noise Types
For best signal-to-noise performance in low frequency IF doppler systems.

MA-4126 MA-4126A	MA-4126R MA-4126AR	MA-4126M MA-4126AM	MA-4126MR MA-4126AMR	MA-4131 MA-4131A	—	2.0 2.0

4,000 Mc — 10,000 Mc

Improved Types
For low noise superheterodyne mixer performance
• Replace 1N23 series

MA-451B	MA-451BR	MA-451BM	MA-451BMR	MA-458B	11.4	2.0
MA-451C	MA-451CR	MA-451CM	MA-451CMR	MA-458C	9.8	2.0
MA-451D	MA-451DR	MA-451DM	MA-451DMR	MA-458D	8.2	2.0
MA-451E	MA-451ER	MA-451EM	MA-451EMR	1N23WE	7.5	2.0
MA-451F	MA-451FR	MA-451FM	MA-451FMR	MA-458F	7.0	2.0

Higher Burnout Types
For use in pulse radars or other receivers exposed to high RF radiation fields.
• Interchangeable with 1N23 series

MA-4133	MA-4133R	MA-4133M	MA-4133MR	MA-4134	9.8	5.0

Lower Noise Types
For best signal-to-noise performance in low frequency IF doppler systems.

MA-4125 MA-4125A	MA-4125R MA-4125AR	MA-4125M MA-4125AM	MA-4125MR MA-4125AMR	MA-4130 MA-4130A	— —	2.0 2.0

10,000 Mc — 18,000 Mc
COAXIAL CASE

Improved Types
For low noise superheterodyne mixer performance
• Replace 1N78 series

MA-443	MA-443R	MA-443M	MA-443MR	—	—	0.6
MA-443A	MA-443AR	MA-443AM	MA-443AMR	—	9.8	0.6
MA-443B	MA-443BR	MA-443BM	MA-443BMR	—	8.8	0.6
MA-445	MA-445R	MA-445M	MA-445MR	—	—	1.0
MA-445A	MA-445AR	MA-445AM	MA-445AMR	—	9.8	1.0
MA-445B	MA-445BR	MA-445BM	MA-445BMR	—	8.8	1.0

Lower Noise Types
For best signal-to-noise performance in low frequency IF doppler systems.

MA-4124 MA-4124A	MA-4124R MA-4124AR	MA-4124M MA-4124AM	MA-4124MR MA-4124AMR	—	—	0.6 0.6

SILICON VIDEO DIODES
1 Mc — 10,000 Mc

Improved Types For high tangential signal-to-noise sensitivity in simplified beacon receivers, test equipment and other uses.
• Replace MA-408 series CARTRIDGE CASE

Fixed Base Types		Reversible Polarity	Burnout (ergs)
Forward Polarity	Reversed Polarity		
MA-452	MA-452R	MA-461	1.0
MA-452A	MA-452AR	MA-461A	1.0
MA-452B	MA-452BR	MA-461B	1.0

Higher Burnout Wide Dynamic Range Types
For use in video receivers exposed to high RF radiation fields.
• Interchangeable with MA-408 series

MA-412B	MA-412BR	MA-4129	5.0

For further information mark No. 43 on Readers' Service Card

educational and industrial buildings has been approved. It established minimum standards covering methods of sound system distribution and the methods of maintaining standards compatible with the quality of the buildings in which such systems are installed.

The standard on power transformers to 1 kva for use in radio, TV and electronic equipment has been revised and resubmitted for approval. In its new form it will include a guide to the manufacturer and user for all the requirements that should be specified in Canadian design.

De Havilland Aircraft of Canada Ltd. wins $1,700,000 contract for development of a counter-missile for the United States Army.

The contract is for development of an infra-red unit for the U. S. Army Mauler missile, designed to intercept aircraft and short-range missiles.

Government Liaison Committee of EIA has been strengthened.

The top policy committee on all matters affecting EIA's contact with Federal government departments has been reorganized. The new structure will have the president of EIA as its chairman, assisted by two senior executives from each of the three divisions of EIA.

The Association recently added two new companies to its list of members: Burndy Canada Ltd. joined the Components Division, and Electronic Research & Development Co., Division of Mandrel Industries Ltd., Calgary, joined the Electronics Division. Sylvania Electric (Canada) Ltd., a member of the Components Division, has joined the Electronics Division too. Canadian Admiral Corp. Ltd. has rejoined the Receiver Division.

Garrett Corp. is moving its avionics operation to Canada.

The avionics operation is being moved from the AiResearch Manufacturing Div., Los Angeles, to Garrett Manufacturing Ltd., Toronto. The move will add an estimated $1.5 million to export production for 1962 and is expected to rise to $7 million annually during the next five years.

Collins Radio Co. of Canada exports UHF communications transceivers.

CEE reported in error (Dec. page 7) that the AN/ARC-504 emergency transceiver is standard equipment on all F-104G and F-104J versions of the Starfighter. It is the AN/ARC-552A communications transceiver which is standard on the G and J versions of the aircraft, in production for West Germany, Belgium, the Netherlands, Italy, Japan, and USAF M.A.P. program. Negotiations are under way regarding export of the new ARC-504 to these nations.

Ottawa report

A crash-program to improve the technical skills of Canada's labor force appears to be making considerable progress.

This program, officially launched by Labour Minister Starr in December 1960, is intended as a cure for unemployment and a way to improve industrial productivity in the face of increasing international competition.

Speaking to the second annual meeting of the National Technical and Vocational Training Advisory Council in Ottawa, Mr. Starr said it was expected that the capacity of technical and vocational training facilities in Canada will be increased by 50% by mid-1963.

This involves an extra 65,000 students at training establishments and a construction program of about $182 million, of which the federal government will be carrying 75% of the financial load.

All told 141 new technical institutes, trade schools and technical and vocational high schools have been approved for construction under the joint federal-provincial program. All 10 provinces are participating. Prince Edward Island has not yet planned any new schools. Quebec, which joined this year, already has an effective technical training program and has so far not requested federal assistance for new construction.

The National Productivity Council will soon begin a program to promote work-study methods in industry.

Appointment of a national director and formation of a work-study unit within the council will be announced shortly.

General aim of the group will be to "promote improved management techniques" throughout industry, particularly in manufacturing, service, distribution and retail sectors. Special emphasis will be placed on labor-management relations.

Concentration will be upon smaller and medium-sized industries where it is felt opportunities for improved management efficiency are greatest.

Several pilot courses of work study will be drawn up. There will be elementary courses for shop foremen, lasting about 10 days, and intensive six-week courses for senior executives.

The council will sponsor, but not underwrite, the courses. They will likely be co-sponsored by provincial bodies, municipal boards of trade, or by groups of firms in one locality.

CREATIVE CONTROVERSY IN INERTIAL GUIDANCE

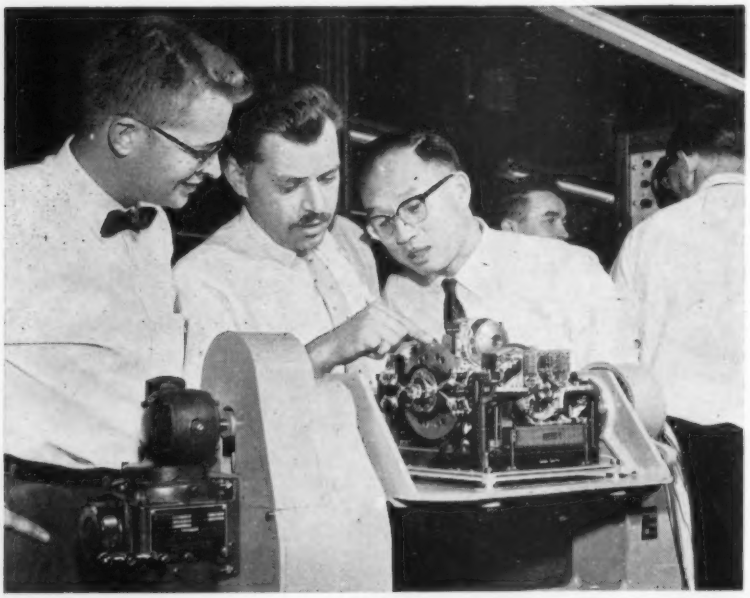
Behind the inertial package you see here is the instructive history of a creative controversy.

It's the history of how the ingenious rebuttals of some Litton Systems people won an engineering debate by overcoming certain obstacles that had been roadblocking progress in airborne inertial navigation.

The equipment shown is the stable-platform unit of a Litton LN-3 navaid system, first to furnish operational aircraft with inertial navigation information to an accuracy within 1.5 nautical miles for each hour of varied flight maneuvers.

The debate: It had been known that an inertial platform could be built around two two-degree-of-freedom gyros in place of the three one-degree-of-freedom gyros that were the standard concept. And that such a change would offer a number of important advantages including high gyro angular momentum in a compact platform, better servo response characteristics, and freedom from air-bubble problems achieved through the use of low-viscosity damping fluid.

Many inertial engineers felt strongly that the difficulties encountered in trying to manufacture two-degree-of-freedom gyros would more than offset the promised benefits. The difficulty regarded with the most superstitious awe was the problem of adjusting the center of gravity, center of buoyancy and total weight of the float containing the gyro to achieve neutral buoyancy at a specified temperature and zero torque about all three axes, within extremely narrow tolerances.

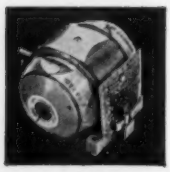


The additional restriction, that the weights placed on the float for balancing shall fall between a minimum and a maximum allowable size, increases the complexity of the actual balance procedure, placing it in the "linear programming" category from a computer standpoint.

The problem was solved by being programmed for solution on a digital computer in order to provide an efficient and reliable balancing process in production. The success of this approach is demonstrated by the world-wide operation of the Litton LN-3 aircraft navigation system, a proven lightweight system of high accuracy that uses two-degree-of-freedom gyros.

The same approach is being used to expedite the development of even more advanced systems, which will assure Litton's dominant position in the field. They include the Litton Doppler-Inertial System for the P3V anti-submarine patrol aircraft and the P-300 inertial platform of the Air Force Flight Data System for orbital and sub-orbital vehicles.

Attractive openings are available for electronics engineers and mechanical technicians with several years assembly experience in any of the following fields—inertial platforms, gyros, accelerometers, servo mechanisms or similar precision mechanical equipment. These are permanent positions in a long term programme. To apply, write to Personnel Manager, Litton Systems (Canada) Limited, 123 Rexdale Blvd., Rexdale, Ontario.



LITTON SYSTEMS
(CANADA) LIMITED
Rexdale, Ontario

DIVISION OF LITTON INDUSTRIES
BEVERLY HILLS, CALIFORNIA

For further information mark No. 42 on Readers' Service Card

Aeromotive Engineering Products appoints new executives

The Directors of Aeromotive Engineering Products Ltd., Montreal, have announced the appointment of Norman Silberberg as president, and F. J. Crombie as secretary.

Mr. Silberberg succeeds Arden C. Boland, who remains as president of Boland Dynamics Ltd., and a director of Aeromotive Engineering Products.

A subsidiary company under the name of A.E.P. — International Ltd. has been incorporated to handle all sales outside of Canada for Aeromotive Engineering Products. Officers of the new company are: H. H. Petzoldt, president; W. J. Smith, vice-president; F. J. Crombie, secretary. A branch office has been opened in London under the supervision of Mr. Smith, who also holds the title of European Area Manager.

Silberberg

Enright

R. C. Enright has joined the sales staff of A. Deskin Sales Corp.

Mr. Enright will serve customers in the southern Ontario region, and will be located at the new Deskin office at 1380 St. Clair Ave. East, Scarborough, Ont. (Pl 7-5008). During the past 10 years, Mr. Enright has been with Philips Electronics Industries Ltd., Canadian Arsenals Ltd., and Cannon Electric Canada Ltd.

C. M. Drury, CBE, DSO, QC, has been appointed president of Needco Cooling Semiconductors Ltd.

He succeeds Roman Post, who will remain on the board of directors, and act as a consultant while devoting his time to Nucleonic Electric Equipment & Development Co. Mr. Drury was Deputy Minister of National Defence from 1949 to 1955, and is president of Avis Transport of Canada Ltd., and vice-president of the Foundation Co. of Canada.

Instronics Limited has announced these new appointments.

Peter Dernick, P.Eng., has been appointed manager of the computer and data processing division of the company. He brings to his new position many years of experience in the digital computer field with Computing Devices of Canada.

Dernick

Cameron

A. Cameron Mem.IRE, has been appointed manager of the company's instrument division. He joined Instronics from the Prince Albert radar laboratory of the Defence Research Board, where he was responsible for much of the operation and maintenance in his capacity as technical officer.

Appointments at the University of Toronto.

P. B. Biringer has been elevated from assistant to associate professor, and **I. R. Dalton** has been appointed to the rank of assistant professor. Both are with the electrical engineering department.

Meyer T. Bentob, has joined the sales engineering staff of Andrew Antenna Corporation, Limited, of Whitby, Ontario.

Formerly with Canadian-Marconi Company, he has had wide experience in antenna system design and development work, both in England and Canada. Mr. Bentob will temporarily make his headquarters in Montreal.

Bentob

Moric

Automatic Electric Sales (Canada) Limited has appointed Paul Moric as sales representative for Alberta.

Mr. Moric, who joined the company's Edmonton sales office two years ago, will be in charge of supplies products for the province.

The University of Waterloo has announced the appointment of Prof. R. G. Anthes as acting chairman of the Electrical Engineering Department.

He succeeds Dr. B. R. Myers. Prof. Anthes graduated from, and taught at the University of Toronto then taught at the University of Manitoba before joining Canadian Westinghouse Ltd. as an advanced development engineer in the Electronics Division.

The university also announced the appointment of **Dr. A. H. Qureshi** and **R. G. Van Heeswijk** as lecturers in the Electrical Engineering Department.

Litton Systems (Canada) Ltd., has appointed L. A. Borth as engineering manager, W. F. Haehnel as systems test manager, and Arthur E. Kennedy as senior liaison engineer in Ottawa.

Mr. Borth is a graduate of Queen's University (BSc) and the University of Toronto (MASc). He has had 14 years' experience in electronics.

Borth

Haehnel

Mr. Haehnel is a graduate of the University of Toronto (BASc). He served on the engineering staff there after graduation.

Mr. Kennedy, a 1951 graduate in radio physics from the University of Western Ontario, served for a number of years with the RCAF, and with Sperry Gyroscope as a sales engineer and contracts administrator.

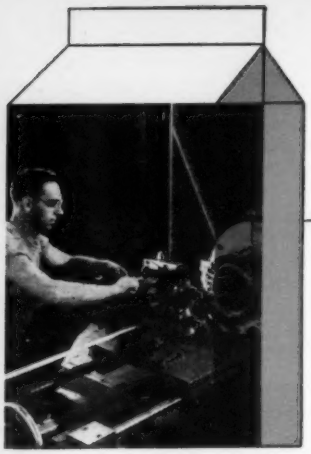
An employment and counselling service has been established by the Association of Professional Engineers of Ontario.

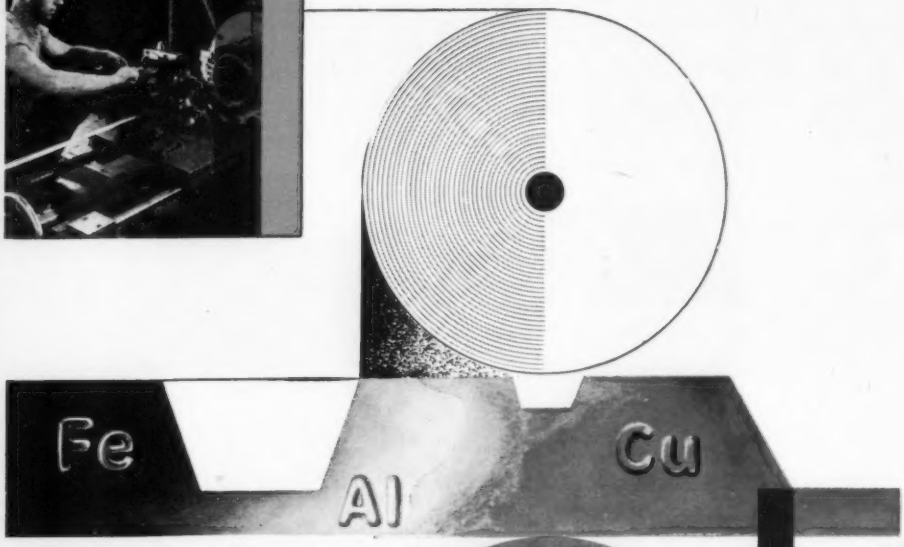
Director of the program is **Blake H. Goodings, P.Eng.,** former field representative of the Association. His successor is **J. O. Harold, P.Eng.**

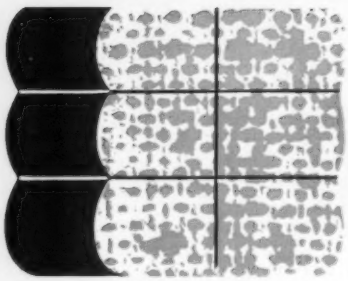
Mr. Goodings served with the RCAF during World War 2, and following graduation in engineering from the University of Toronto, he joined the Canadian Army. Returning from the Korean War, he graduated from the Army's Staff College, Kingston.

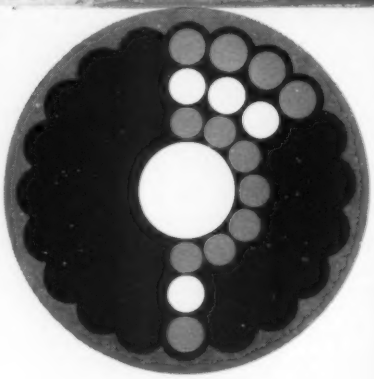
Mr. Harold, who served with the Canadian Navy during World War 2, is a graduate in mechanical engineering from Queen's University. He held the position of plant engineer at the Sanderson-Harold Co. Ltd., and is a past president of the Grand Valley Group of Engineers.

SERVING CANADA THE NORTHERN WAY









...from Canada's forests, mines and factories come raw materials, component parts and complete assemblies which go into the numerous products of Northern Electric. This Northern Electric policy to support Canadian industry is an ever-growing one. Northern Electric designs, manufactures and installs a large proportion of Canada's telephone communication systems and equipment. It includes the manufacture of electrical wires and cables for communications and power transmission, and the distribution of a complete line of electrical apparatus and supplies. At Northern Electric, product research and development never stop and continuing progress is made in the communication, electrical wire and cable fields.

Northern Electric
COMPANY LIMITED

6661-6

For further information mark No. 46 on Readers' Service Card

Hewlett-Packard forms Canadian sales company

The new company, Hewlett-Packard (Canada) Ltd., will be responsible for all sales and service of the parent company's products in Canada. Its principal office, warehouse and service facility will be at 8270 Mayrand St., Montreal. (Telephone: 735-2273).

Branch offices will be at 1762 Carling Ave., Ottawa (Telephone: PA 2-8162), and 1415 Lawrence Ave. West, Toronto (Telephone: 249-9196).

The Canadian offices begin operations January 1, 1962, under the direction of Ralph Haywood.

Prior to joining Hewlett - Packard, Mr. Haywood was eastern regional manager of R-O-R Associates Ltd. He has also served with the research and development staff of RCA Victor Co. Ltd., Montreal. He graduated from the University of Manitoba in electrical engineering.

Atlas Instrument Corp., which has been the Canadian sales representative for Hewlett-Packard, will maintain a service facility for the latter's instruments in the Toronto area.

Canadian firm becomes sole source of Ungar Electric products

Eldon Industries of Canada Ltd., has been appointed by their parent company as the world source for all Ungar Electric Tool products. This change will mean a considerable increase in Canadian production by Eldon Industries of Canada (formerly Astral Electric Co. Ltd.) and will add to Canada's export drive.

Union Carbide Canada will start producing tantalum capacitors

The Consumer Products Division of Union Carbide Canada Ltd. will start producing Kemet solid tantalum capacitors early next year. MEL Sales Ltd., Melcom Division, has been appointed as the authorized sales representative for Canada.

Lenkurt Electric makes second addition to plant

For the second time since their move to Burnaby, B.C. in 1956, Lenkurt Electric Co. of Canada Ltd. is expanding its factory and offices to accommodate increased production requirements. Construction is nearing completion on the 40,000 sq. ft. addition, which will bring the total building area to 74,000 sq. ft.

The new wing will provide new facilities for the engineering and development work which is being expanded. Lenkurt is currently prime contractor on the B. C. Telephone tropospheric scatter system extending from the north end of Vancouver Island to Alaska, and in the east, is prime contractor for a new communications network for Quebec Hydro. It is shipping equipment to every province in Canada, and in the export market—to Turkey, Venezuela, Mexico and Ceylon.

New company formed to handle industrial control equipment

A new company has been formed to take over the activities of the industrial control division of Measurement Engineering Ltd. The new firm will be known as Measurement and Control Engineering Ltd. D. A. Bamford, P. Eng. will be president of both companies.

Ontario office of the new firm is 71 Crockford Blvd., Scarborough, Ont. (Toronto exchange: 755-9235 or 421-3581). Montreal office is P. O. Box 1352, Station O (Telephone: NA 7-4313).

Wanted! Components for KA band radar transceiver

Hunting Survey Corp. Ltd., P. O. Box 1001, Malton, Ont., is developing a KA band (35 Gc) radar transceiver and is seeking suppliers of the following components.

(1) KA band waveguide sections complete with fittings for pressurization. It is desirable that automatic metering of the gas from a high pressure reservoir be provided.

(2) KA band waveguide components which will permit continuous monitoring of the internal waveguide pressure and supply a remote warning in the event of failure.

Suppliers should contact Mr. D. M. Scott.

New company will specialize in components and sub-assemblies

Leigh Instruments Ltd., P. O. Box 1155, Carleton Place, Ont. (Telephone 747), has been formed to design and produce electronic and electro-mechanical components and sub-assemblies, such as servo amplifiers, magnetic clutches and gear boxes. The principals include C. W. Mott, former vice-president of Central Dynamics Ltd., M. Price, formerly a design engineer with Central Dynamics Ltd., and J. J. Shepherd (president and general manager), formerly with Computing Devices of Canada Ltd.

New principals, representatives and services

The Ahearn & Soper Co. Ltd. has been appointed Canadian sales representative for **Metcom, Inc.,** Salem, Mass., designers and manufacturers of microwave tubes and devices.

Electronic Marketing Co. of Canada Ltd., has acquired the following principals: **United Components, Inc.,** Orange, N.J., manufacturers of silicon rectifiers and diodes; **Technipower Inc.,** South Norwalk, Conn., manufacturer of solid state dc power modules.

General Magnetics Inc., Minneapolis, (current transformers, solenoid valves, street lighting equipment and specialty products) has appointed Lisle Instrument Systems Ltd. as its Canadian representative.

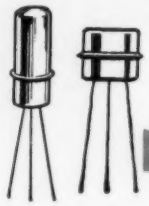
Willer Engineering & Sales Co. has been appointed Canadian sales representative by **Engineered Electronics Co.,** Santa Ana, Calif. (packaged circuit modules) and **The Sippican Corp.,** Marion, Mass. (precision welding equipment. Also, the company has been appointed sales representative in the Toronto and Western Ontario region by **Emerson & Cuming, Inc.,** Canton, Mass.

Atlas Radio Corp. has been appointed Canadian sales representative by the following companies: **U. S. Transistor Corp.** of Syosset, N.Y. (germanium junction transistors and tunnel diodes), **Continental Device Corp.** of Hawthorne, Calif. (silicon junction diodes), and **Mark Simpson Mfg. Co. Inc.** (Masco sound and intercom equipment).

Microwave Components and Systems Corp., Monrovia, Calif., has appointed M. J. Howard & Co. Ltd. as its Canadian sales representative. Products are microwave components and sub-assemblies.

Airflite Components Co. has been named Canadian representative by **Astro Controls Inc.,** and its divisions, Clairtron Mfg. Co. and Crown Electric Prod., all of Montclair, N.J. (thermal time delay relays, thermostats, magnetic relays and flashers). The company also has been named Canadian representative by **Modular Electronics Corp.,** Los Angeles, manufacturer of terminal blocks, lugs and connectors.

PHILCO® The world's most



COVERS THE ENTIRE USEFUL

MICRO ALLOY DIFFUSED-BASE TRANSISTORS (MADT*)

TYPE	GAIN h_{FE}	FREQUENCY f_{max} in mc	APPLICATIONS
2N499	10 db @ 100 mc	320	VHF amplifier; MIL specifications
2N501	70	Switching rates 20 mc	Ultra-fast switch; typical t_r 11 mμsec, t_s 8 mμsec, t_f 8 mμsec
2N501A	95	Switching rates 20 mc	Ultra-fast switch; typical t_r 10 mμsec, t_s 7 mμsec, t_f 7 mμsec; MIL specifications
2N502	12 db @ 200 mc	800	VHF amplifier and oscillator
2N502A	12 db @ 200 mc	800	Rated at 100°C; MIL specifications
2N503	12.5 db @ 100 mc	350	VHF amplifier
2N588	14 db @ 50 mc	250	General purpose RF-IF amplifier
2N768	40	f_T 175	High-frequency micro-energy switch
2N769	55	f_T 900	Ultra-fast switch for low-level, high-frequency logic circuits
2N779A	90	Switching rates 20 mc	Very high-speed switch
2N846A	50	Switching rates 20 mc	Very high-frequency switch
2N1158	30 mw PO	at 200 mc	VHF power oscillator
2N1158A	35 mw PO	at 200 mc	VHF power oscillator; MIL specifications
2N1204	30	Switching rates 25 mc	High current switch & core driver
2N1494	30	Switching rates 25 mc	High current, high power switch & core driver
2N1495	30	Switching rates 25 mc	Higher voltage version of 2N1204
2N1499A	70	Switching rates 10 mc	High-speed, saturated switch; MIL specifications
2N1500	70	Switching rates 20 mc	Ultra-fast switch; typical t_r 13 mμsec, t_s 7 mμsec, t_f 7 mμsec; MIL specifications
2N1726	60	150	6-12 volt radio RF amplifier
2N1727	60	150	6-12 volt radio converter
2N1728	60	150	6-12 volt radio IF amplifier
2N1742	33	1300	UHF and VHF amplifier
2N1743	33	1300	UHF and VHF mixer
2N1744	33	2.5 mw PO at 257 mc	VHF oscillator
2N1745	33	800	45 mc IF amplifier
2N1746	60	235	4.5 mc unneutralized IF amplifier
2N1747	60	250	6-12 volt radio FM IF amplifier
2N1748	h_{fe} 45	f_T 115	Video driver
2N1748A	h_{fe} 70	f_T 132	Video driver; higher beta 2N1748
2N1749	h_{fe} 45	f_T 115	Video output; higher voltage 2N1748
2N1752	h_{fe} 250	106	High beta TV sync separator
2N1754	75	Switching rates 10 mc	High-speed saturated switch
2N1785	60	125	3 to 6 volt radio RF amplifier
2N1786	60	125	3 to 6 volt radio converter
2N1787	60	125	3 to 6 volt radio IF amplifier
2N1788	60	150	12 volt auto radio RF amplifier
2N1789	60	150	12 volt auto radio converter
2N1790	60	150	12 volt auto radio IF amplifier
2N1864	50	125	Reflex amplifier in broadcast receivers
2N1865	60	250	6-9 volt radio AM/FM IF amplifier
2N1866	60	250	12 volt auto radio AM/FM IF amplifier
2N1867	60	250	12 volt auto radio FM IF amplifier
2N1868	33	800	45 mc TV IF amplifier; 19 db PG @ V_{CE} = —4.5v

MICRO ALLOY TRANSISTORS (MAT*)

TYPE	GAIN h_{FE}	FREQUENCY f_T in mc	APPLICATIONS
2N393	50	50	High-speed, high-gain switch; MIL specifications
2N1122	50	60	High-voltage, high-speed switch
2N1122A	50	60	Higher voltage version of 2N1122
2N1411	50	50	High-frequency switch; MIL specifications
2N1427	75	75	General purpose, high-speed switch

SILICON SURFACE ALLOY TRANSISTORS (SAT*)

TYPE	GAIN h_{fe}	FREQUENCY f_{max} in mc	APPLICATIONS
2N495	35	18	General purpose; MIL specifications
2N496	h_{FE} 25	f_T 20	High-speed switching; MIL specifications
2N1118	35	18	General purpose; MIL specifications
2N1118A	25	18	General purpose amplifier, high beta (15-35)
2N1119	h_{FE} 25	f_T 20	High-speed switching; MIL specifications
2N1428	45	23	General purpose, low-cost, high-frequency, silicon amplifier and switch; TO-1 case
2N1429	45	23	General purpose, low-cost, high-frequency, silicon amplifier and switch; TO-5 case
2N1676	50	42	Chopper at rates in excess of 50kc
2N1677	50	32	Chopper at rates in excess of 40kc

SILICON SURFACE ALLOY DIFFUSED-BASE TRANSISTORS (SADT*)

TYPE	GAIN h_{fe}	FREQUENCY	APPLICATIONS
2N770	h_{FE} 25	Switching rates 5 mc	NPN high-speed switch with controlled switching characteristics
2N771	h_{FE} 50	Switching rates 5 mc	NPN high-speed switch with controlled switching characteristics
2N772	h_{FE} 35	Switching rates 5 mc	NPN high-speed switch with controlled switching characteristics
2N773	11	25 db at 4.3 mc	NPN narrow and wide band 4.3 mc video amplifiers
2N774	20	25 db at 4.3 mc	
2N775	50	25 db at 4.3 mc	
2N776	11	25 db at 12.5 mc	NPN narrow and wide band 12.5 mc video amplifiers
2N777	20	25 db at 12.5 mc	
2N778	50	25 db at 12.5 mc	
2N1199	h_{FE} 25	f_T 125 mc	NPN high-speed silicon switch; max t_r 70 mμsec, t_s 20 mμsec, t_f 40 mμsec
2N1199A	h_{FE} 25	f_T 125 mc	NPN high-speed silicon switch; max t_r 55 mμsec, t_s 20 mμsec, t_f 35 mμsec; MIL specifications
2N1267	11	25 db at 4.3 mc	NPN silicon amplifiers and oscillators
2N1268	20	25 db at 4.3 mc	
2N1269	50	25 db at 4.3 mc	
2N1270	11	25 db at 12.5 mc	NPN silicon amplifiers and oscillators
2N1271	20	25 db at 12.5 mc	
2N1272	50	25 db at 12.5 mc	
2N1472	h_{FE} 35	Switching rates 5 mc	NPN high frequency switch
2N1663	h_{FE} 50	Switching rates 5 mc	NPN high frequency switch

INDUSTRIAL SEMICONDUCTOR DISTRIBUTORS

ONTARIO
Electro Sonic Supply Co. Ltd.,
543 Yonge Street,
Toronto

NEW BRUNSWICK
NOVA SCOTIA
NEWFOUNDLAND
Commercial Equipment Ltd.,
King Street,
Saint John, New Brunswick

QUEBEC
Canadian Electrical Supply Co. Ltd.
275 Craig Street, West,
Montreal

complete line of transistors!

FREQUENCY SPECTRUM

SILICON PRECISION ALLOY TRANSISTORS (SPAT**)

TYPE	GAIN h_{FE}	FREQUENCY f_T in mc	APPLICATIONS
2N858	20	14	Medium-speed transistor for control and switching circuits
2N859	35	14	Medium-speed transistor for control and switching circuits and high gain amplifiers
2N860	20	14	Medium-speed transistor for control and switching circuits
2N861	35	22	Medium-speed transistor for control and switching circuits and high-gain amplifiers
2N862	20	14	Medium-speed transistor for control and switching circuits
2N863	35	22	Medium-speed transistor for control and switching circuits and high-gain amplifiers
2N864	35	22	Medium-speed transistor for control, switching and chopper circuits
2N865	75	52	High gain DC and audio amplifiers and control circuits

SURFACE BARRIER TRANSISTORS (SBT**)

TYPE	GAIN h_{fe}	FREQUENCY f_{max} in mc	APPLICATIONS
2N128	40	60	General communications; MIL specifications
2N232	22	50	IF amplifier for AM radios
2N240	30	Switching rates 20 mc	High-speed switch; controlled hole storage and saturation characteristics; MIL specifications
2N344	22	50	General purpose; narrow beta spread (11-33)
2N345	35]	50	General purpose; similar to 2N344 with higher beta
2N346	35	75	General purpose; like 2N344 and 2N345 but higher frequency
2N1730	h_{FE} 40 max	50	Horizontal oscillator in television receivers

MINIATURE TRANSISTORS

TYPE	GAIN h_{fe}	FREQUENCY f_{hfb} in mc	APPLICATIONS
2N207	100	2	Low level amplifier; particularly suited for hearing aid use; N.F.† 15 db max
2N207A	100	2	Low level amplifier; particularly suited for hearing aid use; N.F.† 10 db max
2N207B	100	2	Hearing aid input stage; other extremely low noise applications; N.F.† 5 db max
2N534	100	1	High voltage amplifier switch
2N535	100	2	Low-level amplifier and switch; N.F.† 10 db max
2N535A	100	2	Low-level amplifier and switch; N.F.† 5 db max
2N535B	100	2	Low-level amplifier and switch; N.F.† 0 db max
2N536	h_{FE} 150	2	Low-level switch at pulse rates up to 150kc

MEDIUM FREQUENCY TRANSISTORS

TYPE	GAIN h_{FE}	FREQUENCY f_{hfb} in mc	APPLICATIONS
2N397	70	8	Medium power general purpose amplifier and switch
2N598	125	f_T 8	400kc logic switching
2N599	175	f_T 16	Logic switching rates up to 1 mc; core driver MIL specifications
2N600	125	f_T 8	500kc switching; 1 watt peak power dissipation for 0.1 sec; stud mount
2N601	175	f_T 16	High-power core driver; typical rise time 0.1 μsec; stud mount
2N1123	70	5	High-voltage power amplifier and switch; stud mount
2N1478	70	8	300kc switching applications

PULSE AMPLIFIER TRANSISTORS

TYPE	GAIN h_{FE}	FREQUENCY f_{hfb} in kc	APPLICATIONS
2N670	160	700	High peak current pulse amplifier; relay driver
2N671	160	700	High power version of 2N670; stud mount
2N672	Min 20 (SAT)	0.5 μsec max t_r	High-current switching core driver; controlled rise, fall and store times
2N673	Min 20 (SAT)	0.5 μsec max t_r	High power version of 2N672; stud mount
2N674	160	1100	75 volt version of 2N670
2N675	160	min 400	75 volt version of 2N671

MEDIUM POWER TRANSISTORS

TYPE	GAIN h_{FE}	FREQUENCY f_{hfb} in kc	APPLICATIONS
2N223	h_{fe} 110	600	Audio driver; exceptional beta linearity
2N1416	h_{fe} 110	600	Matched pair of 2N223's
2N224	90	510	Audio output; exceptional beta linearity
2N225	90	510	Matched pair of 2N224's
2N226	60	400	Audio output and switch; exceptional beta linearity
2N227	60	400	Matched pair of 2N226's
2N1124	h_{fe} 125	1300	High-voltage, general-purpose industrial amplifier and switch
2N1125	95	2000	High-voltage, medium-frequency amplifier and switch
2N1128	h_{fe} 120	1250	Exceptionally linear beta; audio driver and output
2N1129	165	750	General-purpose, high beta, audio and switch
2N1130	110	950	General-purpose audio and switch; exceptional beta linearity

POWER TRANSISTORS

TYPE	GAIN	FREQUENCY f_{hfe} in kc	APPLICATIONS
2N386	33 db at 5w PO	14	High-voltage, high-power amplifiers, servo amplifiers, converters and switches
2N387	33 db at 5w PO	12	High-voltage, high-power amplifiers, servo amplifiers, converters and switches

*Trademarks Reg. U.S. Pat. Off.
**Trademark Philco Corp.
†Noise Figure at 1 μv reference level across 1,000 ohms

TRANSISTOR CENTER CANADA

Immediately available in quantities 1-99 from your Philco Industrial Semiconductor Distributor

PHILCO *government and industrial division*

PHILCO CORPORATION OF CANADA LIMITED, DON MILLS, ONTARIO

For further information mark No. 48 on Readers' Service Card

10 mV - 10 V at frequencies up to 800 Mc/s

Internal calibration

It should be noted that all Philips electronic voltmeters contain calibration standards which enable the user easily and rapidly to check, and, if necessary, to re-calibrate his voltmeter at any time without the use of additional instruments.

PHILIPS *electronic measuring*

Sold and serviced by Philips Organizations all over the world.

Further information will gladly be supplied by:

Philips Electronics Industries Ltd.,

116 Vanderhoof Ave., Toronto 17, Ont. - Montreal: 8525 Decarie Blvd.

VHF voltmeter, type GM 6025

requency range
.1 Mc/s - 800 Mc/s flat from 1 Mc/s - 300 Mc/s *(see graph)*
- 1dB at 0.1 Mc/s
- 1dB at 800 Mc/s

Measuring range
) mV (f.s.d.) - 10 V divided into 7 ranges in a 1-3-10 sequence.

ccuracy
he overall accuracy is better than 5% with respect to full scale.

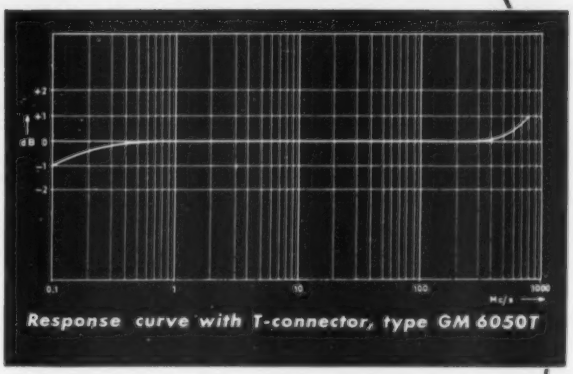
nput impedance
nput capacitance: 1 μμF
nput resistance at:
1 Mc/s 65 kΩ
100 Mc/s 50 kΩ
200 Mc/s 35 kΩ

inear scale
hanks to voltage-dependent feed-back the scale is linear. It is alibrated directly in the r.m.s. value of the VHF voltage and has an ffective length of 5".

alibration voltages
he frontpanel contains a calibration socket which for any setting f the range selector provides the appropriate calibration voltage or that range.

eplacement of the probe crystal
he probe crystal can be easily replaced and the instrument rapidly e-calibrated by the user.

oaxial T-connector
or measurements on 50Ω-coaxial lines the T-connector, type GM 050T can be ordered separately.



Response curve with T-connector, type GM 6050T

other voltmeters from our range

type GM 6012
2 c/s - 1 Mc/s
1 mV (f.s.d.) - 300 V

type GM 6014
1 kc/s - 30 Mc/s
1 mV (f.s.d.) - 30 V

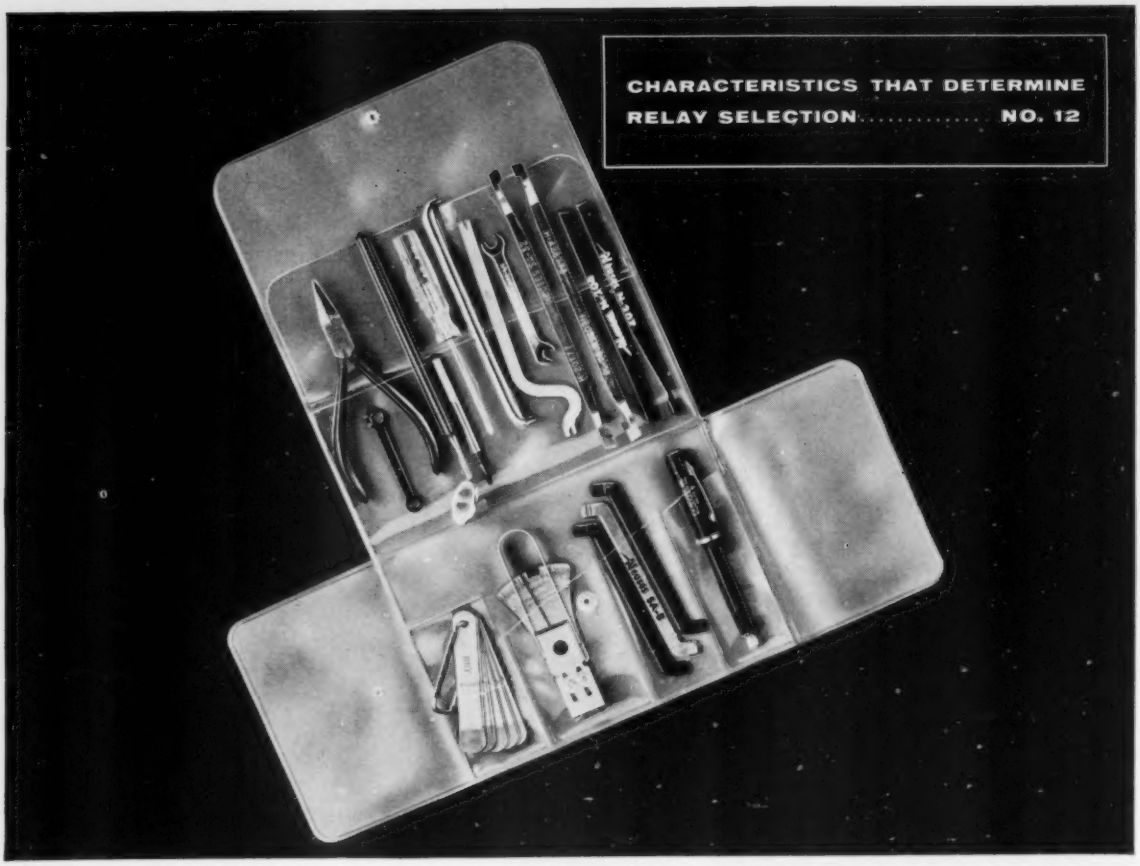
type GM 6020
D.C.
100 μ V (f.s.d.) - 1000 V

μV mV V

instruments: quality ***tools*** for industry and research

PHILIPS

For further information mark No. 49 on Readers' Service Card



The TK-18 Tool Kit — selected tools for almost every relay requirement.

availability of related precision tools

Helpful selection data—Neuses Tools

No. 3-316: "Non-Residual" contact burnisher. Leaves no filings or dust.

No. CB-5: Pocket type burnisher with replaceable blades.

No. SA-9: Reverse curve type wrench. .064″ slots stepped down to .032″ each end.

No. SA-18: Spring adjuster, offset with .018″ lengthwise slots.

No. N-84: Flat nose precision pliers 3″ long.

No.N-206: Offset precision screwdriver.

No. N-376A: Magnifying inspection mirror with insulated handle.

No. STG-2-D: Spring tension gauge, 50-0-50 gram range in 5 gram steps.

Even relays by Automatic Electric sometimes need attention—but because they are manufactured to extreme tolerances, makeshift tools or gadgets are not the answer. In fact they can very easily cause costly damage. Where attention *is* necessary—as when contacts require burnishing or springs need more precise adjustment, only tools specifically made for the job should be used.

The Neuses range of small tools for communication, telephone and electronic equipment are the ideal answer. Distributed in Canada by Automatic Electric, they include every tool to meet every relay requirement. The TK-18 Kit for instance—the simplest and most economical way to buy—contains wrenches, spring adjusters, an insulated contact burnisher, a set of thirteen thickness gauges, screwdrivers and many other tools—all of the finest quality on the market. And the complete Neuses range includes everything from cable strippers and sewing needles to nylon cleaning brushes.

For complete details, call or write Automatic Electric Sales (Canada) Limited, 185 Bartley Drive, Toronto 16, Ontario. Branches across Canada.

AUTOMATIC ELECTRIC

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

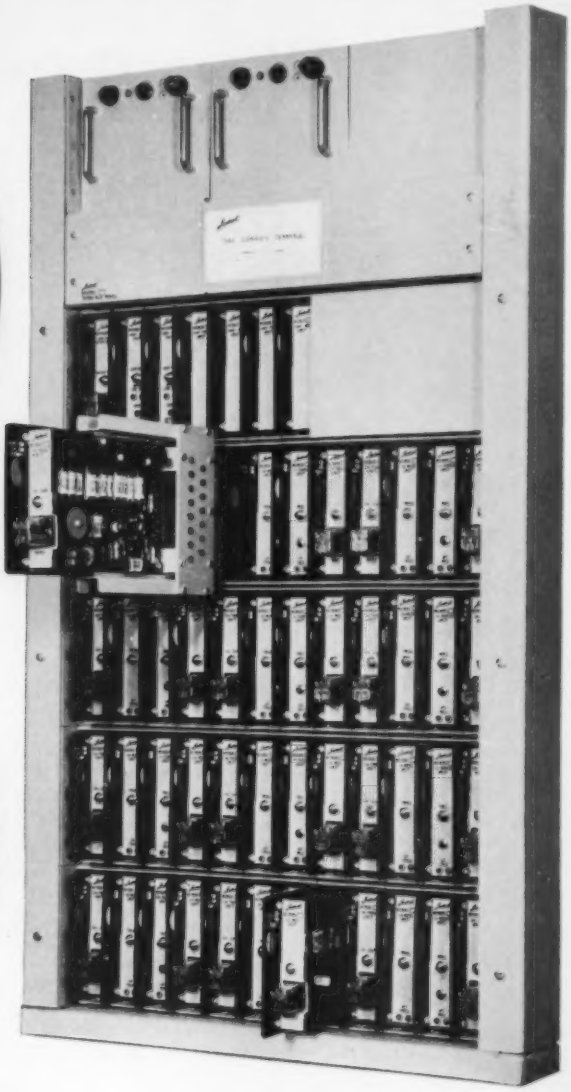
GENERAL SYSTEM

6113

An Organization Serving Canadian Industries With Communication and Control Systems.

For further information mark No. 15 on Readers' Service Card

34A CARRIER SYSTEM



COMPACT

LOW INITIAL COST

UNITIZED CONSTRUCTION

MINIMUM MAINTENANCE

SYNCHRONIZED

71-43-11

The type 34A Carrier System is a fully transistorized stackable, single sideband supressed carrier system operating in the frequency range between 4 kc and 112 kc and has been designed primarily for light-route radio applications. Full synchronization and economical party line operation are only two of the many features of this new 24 channel system.

For further information contact Lenkurt Electric Co. of Canada, Ltd., 7018 Lougheed Highway, North Burnaby P.O., Vancouver, B.C., or any of our district offices in major cities across Canada.

LENKURT ELECTRIC

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

For further information mark No. 41 on Readers' Service Card

Access Fasteners:

How Quick is Quick?

By J. K. Barry
Chief Product Engineer
Southco Div., South Chester Corporation

A dangerous temptation to overspecify often creeps into the process of calling out a quick-access fastener. It becomes possible even for the most experienced product designer to place so much emphasis on speed of operation that other aspects of good design practice may suffer.

Except in rare cases it is doubtful that a difference of 2 to 4 seconds in the time required to actuate a fastener will be a vital matter to the operator. This is especially true when only one or two fasteners are used on a door or panel. The access time element, however, becomes more significant when a greater number of fasteners must be operated to open a single door.

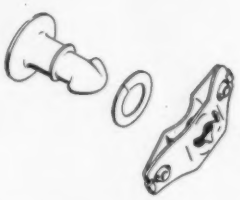
Of equal importance in the selection of a fastener are such considerations as simplicity of design, strength of construction, smoothness of operation, and ability to overcome panel deformation and variation in material thickness.

A quick release fastener that will perform smoothly under conditions of precise alignment and uniform material thickness might be difficult or slow to operate where thicknesses vary and doors become misaligned. But a fastener designed to open with several turns (or a quarter-turn pawl fastener with a self-adjusting feature) might offer quicker access and less trouble by compensating for variations in material and alignment.

Select a fastener suited to the conditions of *your* application. Look for one that can be purchased from stock and installed easily with standard production equipment.

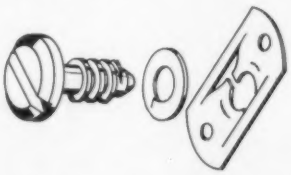
Consider fastening in the early stages of design. You'll avoid the unpleasant choice between redesigning your package at the last minute, or inventing an expensive fastener to fit it.

Shown below are some basic forms of the turn-operated quick-access fastener as made and stocked by Southco. Many major variations in design as well as differences in size, head style, etc. will be found in the new Southco Fastener Handbook. Send for your free copy today. Write to your nearest distributor listed below.



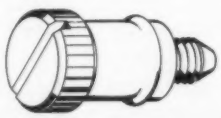
Lion Quarter Turn Fastener

For split-second actuation. Meets Mil Spec MIL-F-5591A (ASG). Excellent under conditions of vibration or where a number of fasteners must be used on the same door.



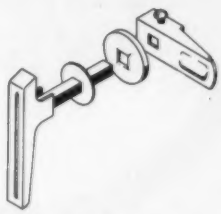
Southco Screw Fastener

Opens with two or three turns. Rugged, quickly installed. Overcomes misalignment of door and frame, tolerates variation in material thickness and deformation of panels.



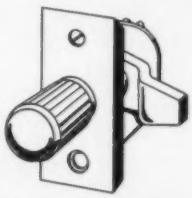
Retractable Screw Fastener

Easily installed by flaring stand-off into door. Captive screw assembly engages tapped hole in frame, needs no receptacle. Ample float tolerates misalignment.



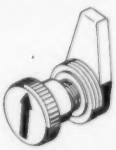
Universal Cabinet Latch

Quickly attached to door with special push-on clip. Fits any door or frame thickness; operates with a quarter turn. Excellent for large doors of gauge metal.



Adjustable Fastener

Pre-assembled and quarter turn operated; latches against frame (even against a rough casting surface). An extra turn of the knob tightens door to compress gasketing, resist vibration. Fits variety of door and frame thicknesses.



Panel Latch

A spring-loaded, quarter turn latch assembled with one set screw. Uses minimum inside space. Arrow indicates pawl position, permits visual inspection.

SOUTHCO FASTENERS
LION
© 1961

Represented in Canada by . . .

METAL AND WOOD FASTENING DEVICES
6302 Papineau Avenue
Montreal 35, Quebec

BLACK BROTHERS, LTD.
1200 Hornby Street
Vancouver, B.C.

WESTAIR SALES CO.
380 Donald Street
Winnipeg 1, Manitoba

METAL AND WOOD FASTENING DEVICES
301 King Street East,
Toronto, Ontario

For further information mark No. 57 on Readers' Service Card

When should you use Mercury-Wetted Contact Relays?

IF YOUR RELAYS MUST

SWITCH UP TO 100 TIMES PER SECOND

HAVE A LIFE IN EXCESS OF A BILLION CYCLES

BE COMPLETELY RELIABLE AND FREE FROM CONTACT BOUNCE

THEN SPECIFY P&B MERCURY WETTED CONTACT RELAYS

An unusual combination of advantages found only in mercury-wetted relays has led many design engineers to specify them for tough switching jobs. Here are but 3 typical characteristics of our JM series:

RELIABILITY. Sealed-in-glass mercury contacts are renewed with every operation. Won't pit or weld. Make or break is positive . . . every time. No bounce, no chatter. Signals ranging from a few micro amps to 5 amps are switched with singular consistency.

LONG LIFE. Think in terms of *billions* of operations when considering JM series relays. Proper application, of course, is a requisite.

SPEED. Operate time is just less than 3 milliseconds using 2 watts of power. Release time is about 3.2 milliseconds. Thus, relays can be driven 100 times per second.

If your project calls for exceptional relay performance, perhaps the answer lies in our JM Mercury-Wetted contact relay.

JM SERIES ENGINEERING DATA

Contact Rating:
5 amperes maximum
500 volt maximum
250 volt-amp max. with required contact protection.

Contact Configuration:
Each capsule SPDT. Combination of capsules in one enclosure can form DPDT, 3PDT, 4PDT. (All Form D.)

Terminals:
Plug-in or hook solder; 8, 11, 14, or 20-pin headers.

Coil Resistance:
2 to 58,000 ohms.

More information?
Write today for free catalogue.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

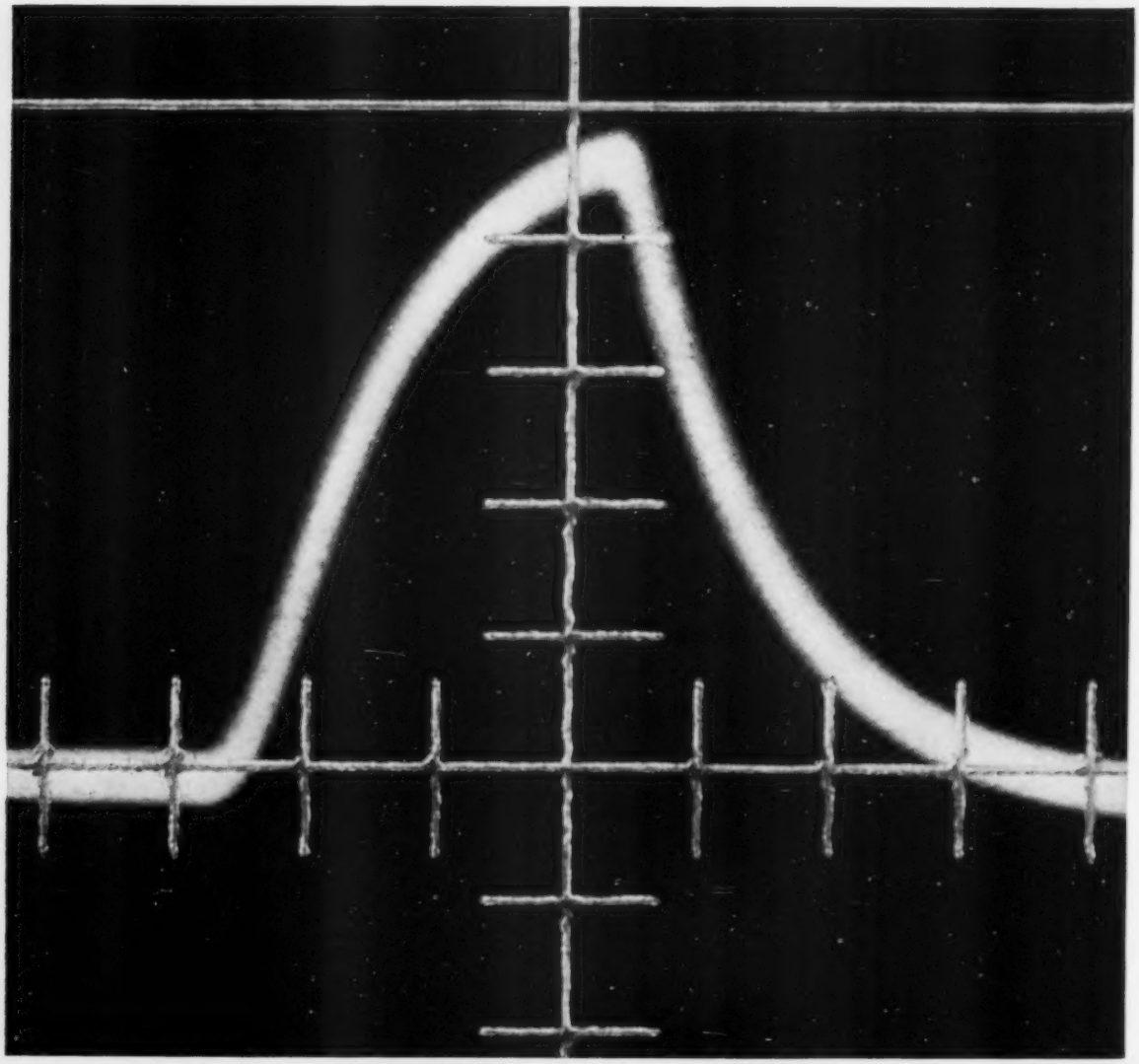
DIVISION OF AMF CANADA LIMITED • OXFORD STREET, GUELPH, ONTARIO

For further information mark No. 50 on Readers' Service Card

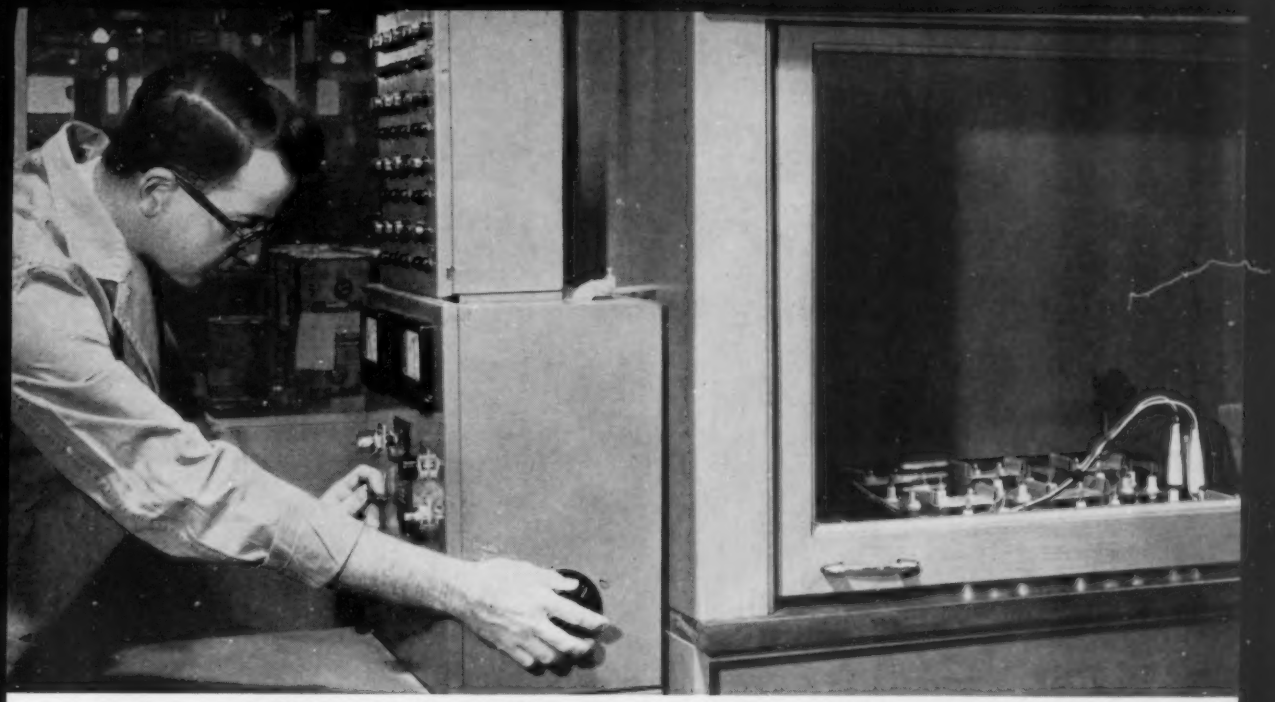
If you build your own memory systems the best way to start is with Ampex Ferrite Cores. These cores are the result of careful selection, and blending of materials, with rigorous quality control during manufacture. Each completed core is tested to precise specifications and those with marginal characteristics are eliminated. Thus you can incorporate Ampex cores into matrices without further testing. In addition to standard storage and switch cores, Ampex manufactures multi-aperature cores for sophisticated applications such as magnetic logic, shift registers, and continuous access storage applications. If you prefer a ready-made memory, Ampex offers more than 40 solid-state models to fill a variety of needs in general purpose computing, automatic control, and in digital data communications, conversion, recording, processing, analysis, editing and multiplexing. These memories range in capacity from hundreds to millions of bits and in memory cycle time from 1 to 24 microseconds. The Ampex RQA Core Memory System, for instance, has a capacity of 32,768 60-bit words, or a total of 1,966,080 bits. Access time of this large capacity memory is 2 microseconds with a memory cycle of 5 microseconds, and 2.5 microsecond buffer systems to your specifications. For complete information on Ampex Ferrite Core Memory components, and systems, write for Literature Packet #CM-45C. Ampex of Canada Limited, Room 607A, Commonwealth Bldg., 17 Metcalfe St., Ottawa, Ontario.

AMPEX

How to store this bit (and up to 1,966,079 like it)



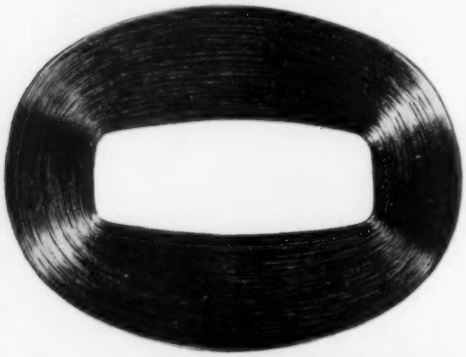
For further information mark No. 12 on Readers' Service Card



Canada Wire EPOXY is being tested for compatibility with supporting insulation materials in this AIEE #510 Motorette Test.

NEW! from Canada Wire

Epoxy insulations help simplify design and reduce production costs! UNIQUE PROPERTIES MEAN COMPLETE COMPATIBILITY IN VIRTUALLY ALL SYSTEMS OPERATING UP TO 130°C.



Canada Wire EPOXIBOND makes shape-retaining coils—without support—hot (200°C) or cold.

EPOXY MAGNET WIRE

EPOXY MAGNET WIRE

Test after test in Canada Wire laboratories proves superiority of Epoxy products.

- 130°C (AIEE Class B) Rating . . . for thermal stability when tested in accordance with NEMA MW-5.
- Compatible . . . with varnishes, encapsulants and supporting insulations.
- Sealed System Tests . . . show no hydrolysis degradation where moisture is present making these magnet wires outstanding for use in totally enclosed and oil-filled systems.
- High dielectric strength . . . under moist conditions.
- High resistance . . . to nuclear radiation and corona degradation.

EPOXY MAGNET WIRE OFFERS PROVEN WINDABILITY PLUS PHYSICAL, CHEMICAL AND ELECTRICAL PROPERTIES WHICH ENSURE SYSTEM RELIABILITY AND PERFORMANCE.

EPOXIBOND MAGNET WIRE

EPOXIBOND MAGNET WIRE

Permits the bonding of wire turns in a coil through heat (140°C-200°C) and offers outstanding advantages in coil winding.

- 130°C (AIEE Class B) Rating . . . for thermal stability when tested in accordance with NEMA MW-5.
- Shape-retaining coils without support . . . wire forms a bond so strong, coil is completely self supporting (no ties or braces necessary). Will bond to paper or metals as well as to itself.
- No increase in overall wire diameter necessary . . . limited flow and dielectric strength of cement coating permits it to be considered as part of the insulation.
- Bond strength . . . retained at temperatures up to 200°C.

ALL THE PROVEN PROPERTIES AND DEPENDABILITY OF EPOXY INSULATION ARE RETAINED IN EPOXIBOND.

QUALITY CABLE IS LOW COST CABLE

Canada Wire and Cable Company Limited

Magnet Wire Division—Simcoe, Ontario

A Canadian Company Manufacturing and Selling Coast to Coast

Sanborn® 7-Channel FM tape system for $6800* complete

uses interchangeable FM and direct record/reproduce electronics entirely contained in 7″ x 19″ panel space

COMPARE PERFORMANCE, PRICE PER CHANNEL

Here is the ideal combination of high performance *and economy* in a 7-channel, 4-speed system that meets IRIG Telemetry Standards. *Versatility* is another advantage. The Model 2000 system uses interchangeable Sanborn FM or direct record/reproduce electronics — all solid-state, in 7″ of panel space — and you can have any combination of direct and FM channels simply by changing circuit cards. Recording capability may be extended beyond the system's minimum input levels through the use of Sanborn "850" and other compatible amplifiers.

The Model 2000 Magnetic Data Recorder has four speeds and uses standard ½-inch tape on 10½-inch reels. All controls are on the front, and several convenience features are included: an integral FM Alignment Meter that eliminates the need for electronic counters, an automatic squelch, a tape footage counter, and provision for using one channel for flutter compensation.

Complete details are available from Sanborn Sales-Engineering Representatives in principal cities throughout the U. S., Canada and foreign countries.

**Price FOB Waltham, Mass., in Continental U. S. A.; subject to change without notice. State and local taxes must be added where applicable.*
(Specifications subject to change without notice)

SPECIFICATIONS

Input ± 2.5 V into 10,000 ohms, single ended, adjustable.

Output ± 2.5 V into 1,000 ohms or more, single ended; level, position adjustable.

Bandwidths (Max)

Speed	*FM*	*Direct*
3¾″/sec	0-625 cps	50-6,250 cps
7½″/sec	0-1,250 cps	50-12,500 cps
15″/sec	0-2,500 cps	50-25,000 cps
30″/sec	0-5,000 cps	100-50,000 cps

(100% modulation on FM = ± 40% carrier deviation)

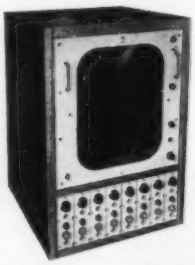
Linearity Maximum error due to nonlinearity: 0.2%.

Drift ± 0.5% of full scale for 10 V power line change, 10°C ambient temperature change, or for 24 hours at constant power line voltage and ambient temperature.

Signal-to-Noise Ratio (Min)

Direct: 40 db at all speeds.

FM: 40 db RMS at 30″/sec and 15″/sec; 35 db RMS at 7½″/sec; 33 db RMS at 3¾″/sec.



Readout, as well as input monitoring during magnetic recording, may be provided by this compatible 17-inch, 8-channel Viso-Scope or other Sanborn monitoring instruments, or by direct writing systems.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Massachusetts

For further information mark No. 54 on Readers' Service Card

We are pleased to announce that, effective June 1, 1961, Amphenol Canada Limited, Toronto, Ontario, acquired exclusive rights and responsibility to manufacture and sell in Canada all electronic components made by RF Products in the United States. Specifically covered by this agreement are both "ipc" and "Amphenol" Coaxial Connectors, "DK" Coaxial Switches and "Amphenol" Coaxial Cable.

AMPHENOL CANADA LIMITED

Toronto
•
Montreal
•
Ottawa
•
Calgary

AVAILABLE NOW

The new MODEL '270'

A custom instrument in the *Simpson* "260" tradition

- Increased accuracy
- Human engineered scales
- Movement overload protection-and a host of other attractive features for discriminating users.

For those who for years have valued the reliability and versatility of the Simpson "260", the Custom-Engineered Model 270 offers a multitude of new features for applications calling for a higher order of accuracy, with no sacrifice in the qualities which have made the "260" famous the world over.

Ranges and scale layouts have been designed for maximum readability with an anti-parallax mirror and knife edge pointer. Precision components and calibration techniques assure accuracies down to ± 1.25% on most of the D.C. ranges, with similar accuracy improvements on other ranges. In addition, the operating manual specifies accuracies on all ranges for a variety of operating conditions, frequency correction curves and a host of useful information.

To conserve this high order of accuracy, a circuit fuse and meter current-limiting diode guard against accidental overload, over and above that provided for in the choice of rugged and generously rated components.

Truly a Custom-Engineered Instrument to suit the present day trend to greater precision in measurement.

Write for further details

Price — $63.07, Sales Tax Included

The Canadian-made Simpson 260 will continue to be available
Price: $55.00
Sales Tax Included

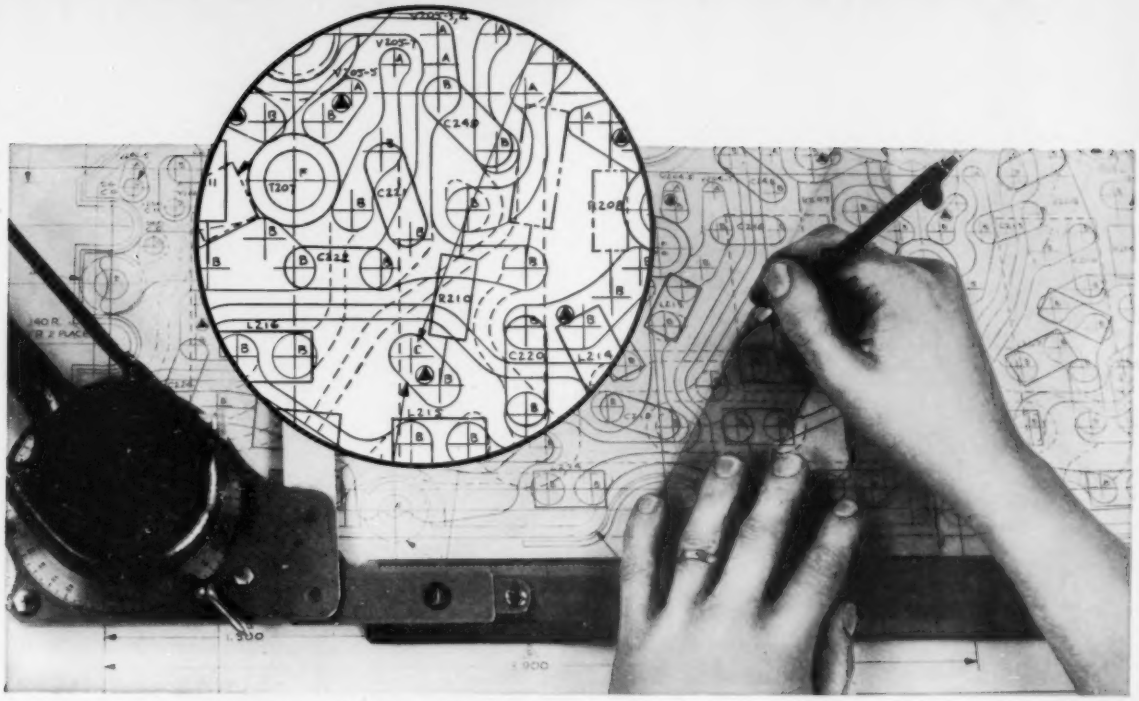
Bach-Simpson LIMITED

1255 Brydges St. London

IN U.S.A.—SIMPSON ELECTRIC COMPANY, 5200 W. KINZIE STREET, CHICAGO 44, ILL.

J-9331

For further information mark No. 17 on Readers' Service Card



Designer drafts master layout of printed circuit design on dimensionally stable CRONAFLEX. Inset shows detail: solid lines indicate circuitry on component side of board; broken lines, circuitry on reverse side.

At Bendix-Pacific...

CRONAFLEX* CUTS COSTS, SPEEDS PREPARATION OF PRINTED CIRCUITS

Versatile CRONAFLEX Engineering Reproduction and Drafting Films have made possible a new, simplified method of preparing printed circuits at Bendix Corporation's Bendix-Pacific Division. Not only has it proven much more efficient and economical, it also assures uniform quality of finished boards and steps up the entire production cycle.

Commenting on the procedure, Edward E. Benjamin, Methods and Design Standards Engineer, says: "CRONAFLEX lets us do a better, faster job, at lower cost, all along the line. For master layouts, where basic design begins, CRONAFLEX Drafting Film is ideal. It holds its size under varying temperature and humidity conditions, takes erasures and handling without damage, and has a far superior matte surface.

"From the master layout we make our master transparency, machine board drawing and assembly board drawing, using CRONAFLEX Direct Positive. Here again results are phenomenal. In the assembly drawing alone, for example, we've cut drafting time from 3-5 days to 4-8 *hours!* Add to this elimination of the negative step, fast printback and excellent halftone quality, and you'll see why we're sold on CRONAFLEX!"

For a FREE booklet that describes this new method in detail, plus information on the many ways CRONAFLEX can help *your* firm cut costs and increase efficiency, clip and mail this handy coupon *now.*

**Registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

Du Pont of Canada Limited
Photo Products
85, Eglinton Avenue East
Toronto 12, Ontario

Please send me without obligation:

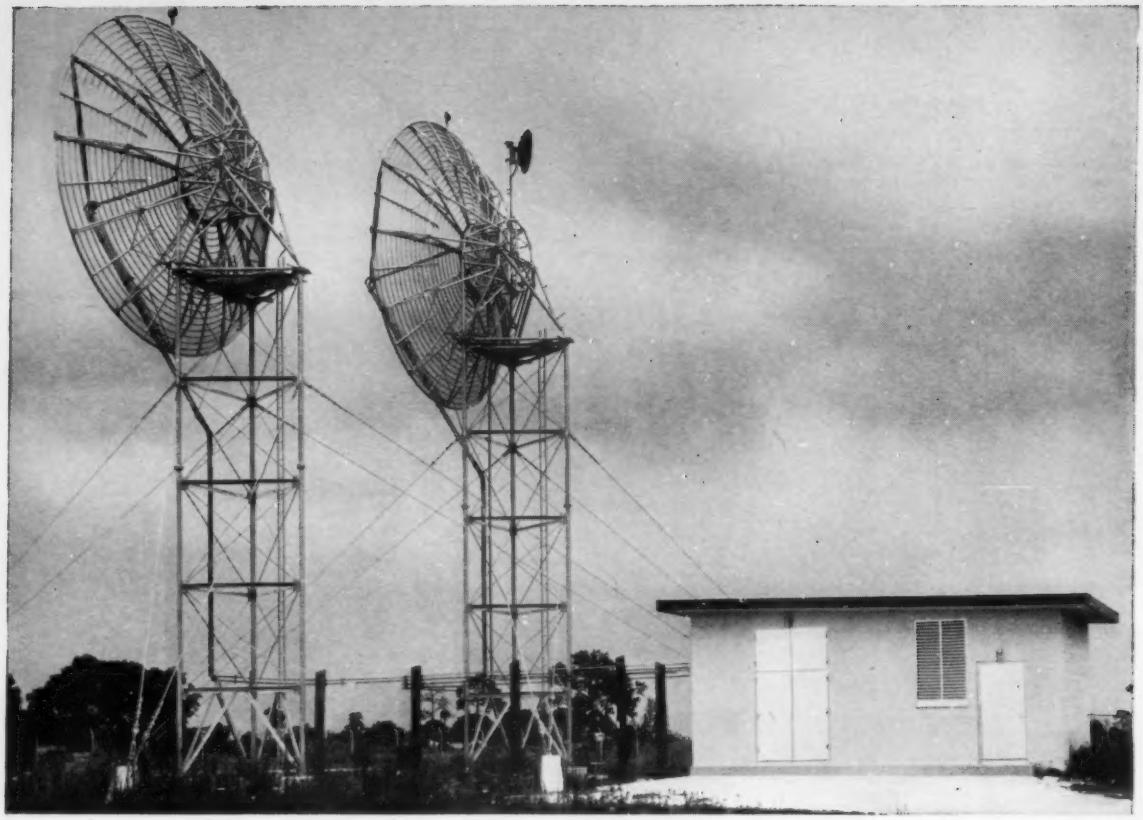
- ☐ Free booklet, "A Photographic Method for Preparing Printed Circuits."
- ☐ Information on the Full Line of CRONAFLEX Engineering Reproduction and Drafting Films.

Name_____
Firm_____
Address_____
City_____ Zone____ Prov._____

DU PONT CANADA

BETTER THINGS FOR BETTER LIVING... *THROUGH CHEMISTRY*

For further information mark No. 29 on Readers' Service Card



NOW IN SERVICE

ON THE 4400-5000 M.C. BAND . . .

WESTINGHOUSE MICROSCATTER BRINGS YOU 4 OPERATING ADVANTAGES AT THIS HIGHER FREQUENCY

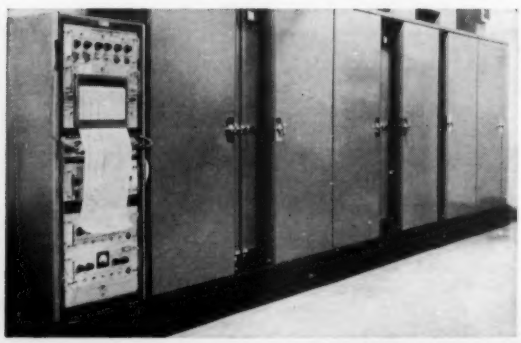
Canadian Westinghouse Company Limited—pioneers in tropospheric scatter at 5000 mc—have supplied equipment for service throughout the world. Operating results substantiate FOUR basic advantages for long range multihop trunk systems.

1. SIZE—Compact radio equipment allows trailer or fixed station installation. Small antennas, 10-28 feet in diameter with high gain. Close antenna spacing, minimum 18 feet centre to centre.

2. PRIMARY POWER—27 kw for 2 kw Quadrupal Diversity terminal, or 14 kw for 2 kw Dual Diversity terminal.

3. FREQUENCY—4400-5000 mc . . . World Wide Licensing and assignments readily obtained.

4. UNATTENDED SITES—Designed for remote operation with proven reliability.



To relate MICROSCATTER to your problem, contact a Westinghouse communications specialist or write to Canadian Westinghouse Company Limited, Electronics Division, Hamilton, Canada.

CANADIAN

Westinghouse

Microscatter

61-A 745

For further information mark No. 24 on Readers' Service Card

Question: Can circuits be simplified with increased reliability?

Answer: Yes!
With the Tung-Sol
dynaquad™
—a four-layer device.

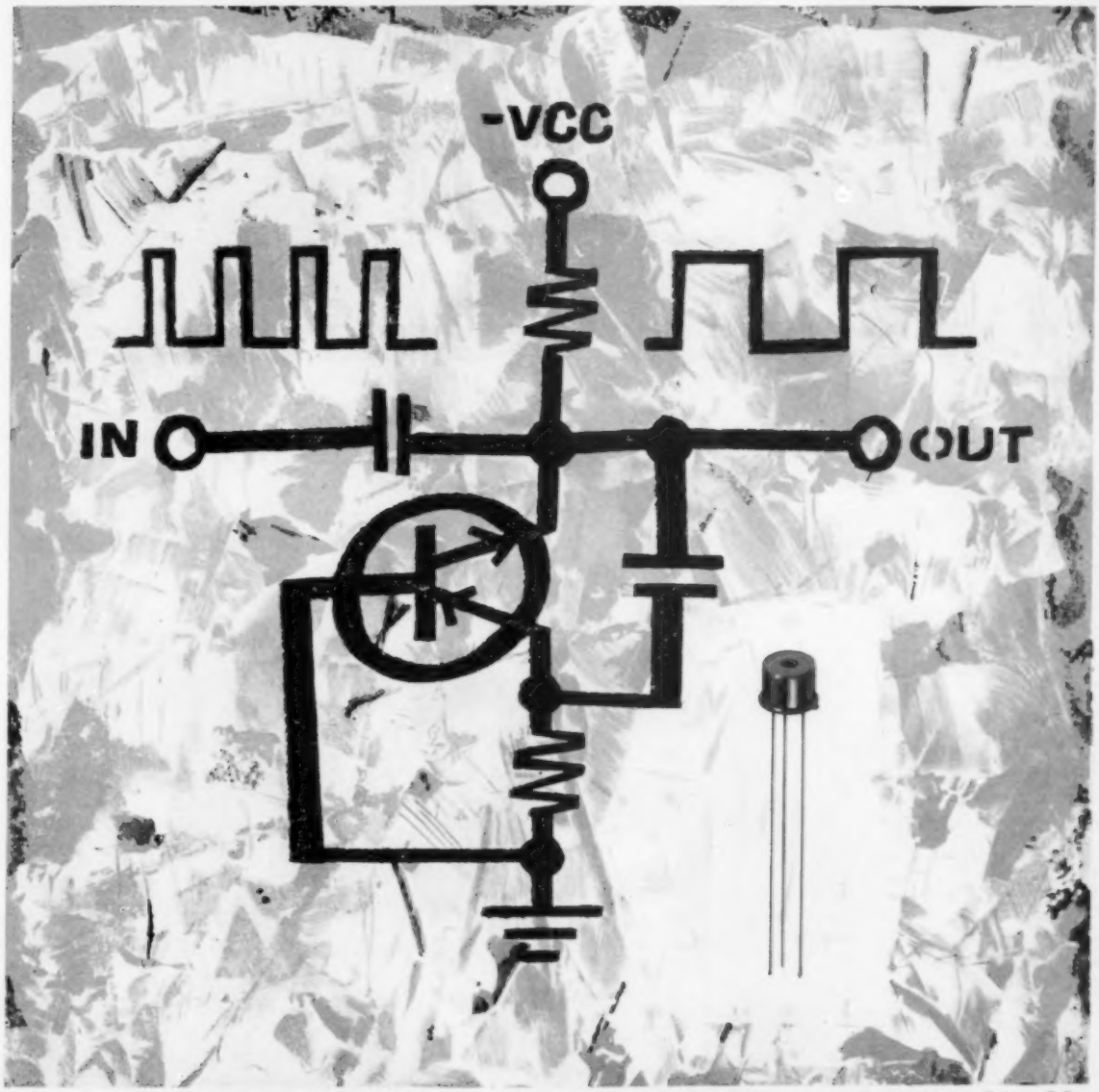
Dynaquad is a PNPN bistable transistor which makes it possible to accomplish flip-flops, binary counters, solid state relays, shift registers and various forms of logic with a saving of one-third to one-half in components and space. In many circuits it directly replaces a number of transistors and their associated components. In others it permits use of transistor techniques where they previously had not been practical.

Finding its chief application in the fields of computation and control, the Dynaquad is a new circuit tool for small signal switching, driving and pulse-forming applications.

Tung-Sol's applications engineers have developed 100 kilocycle shift registers and a 1 megacycle reversible ring counter, using amazingly few components. Circuit diagrams and complete design information are available on request. With great simplicity, bistable, monostable and astable multi-vibrators can be fabricated, using the Dynaquad. One such example is shown below. You are also invited to discuss any special questions you may have with Tung-Sol's applications engineers. Tung-Sol Electric Inc., Newark 4, N. J. TWX:NK193

TECHNICAL ASSISTANCE AVAILABLE THROUGH: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Irvington, N.J.; Melrose Park, Ill.; Newark, N.J.; Seattle, Wash. In Canada: Abbey Electronics, Toronto, Ont.

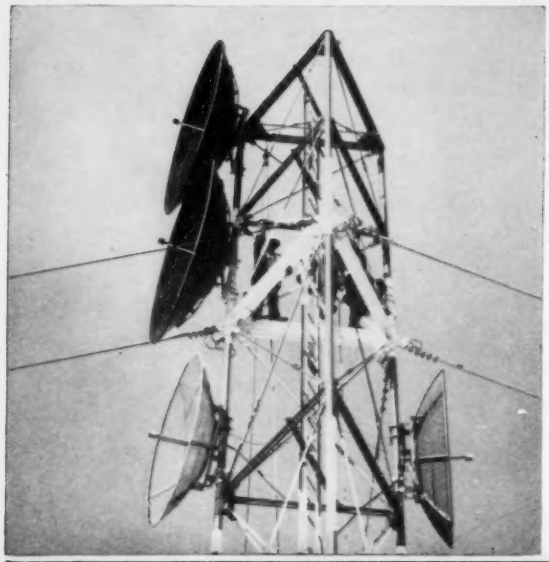
TUNG-SOL®

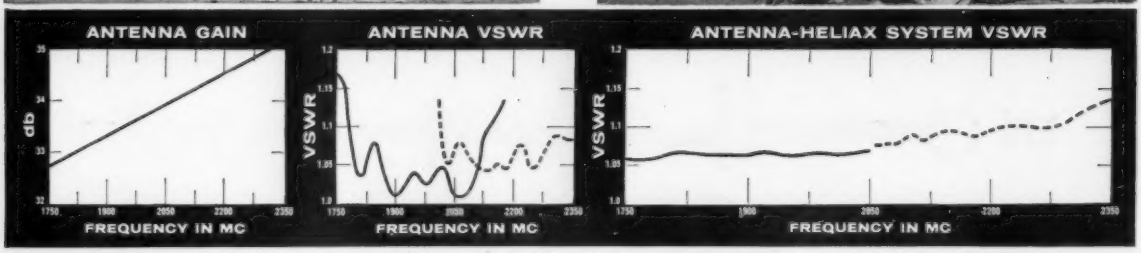


Two resistors, two capacitors and one Dynaquad make a bistable.

For further information mark No. 61 on Readers' Service Card

NO MARGIN FOR ERROR...





Antenna performance based on 60% gain factor

High and low band antenna VSWR plots of production test samples

Test results of high and low band production antennas and 110 feet of 7/8 inch HELIAX cable

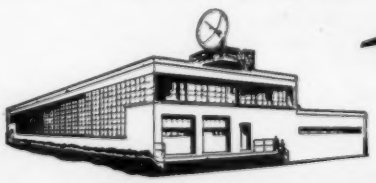
A 600-channel microwave system to carry vital defence data was recently developed by Canadian-Marconi Company for the Royal Canadian Air Force. Because of its strategic value, this long haul line-of-sight system demanded reliable performance in the antenna equipment.

ANDREW Antenna Corporation, Ltd. is proud to have been chosen to design and produce this equipment to meet specific system requirements.

ANDREW microwave antenna, Type 21362, designed for this 1790-2260 mc system guaranteed a VSWR under 1.1. Minimum antenna gain of 33 db resulted from production models having gain factors of better than 60%. The antenna characteristics were sustained in the system through the use of ANDREW HELIAX, the flexible air dielectric cable. HELIAX was chosen for its low VSWR and attenuation, ease of handling and mechanical stability.

Automatic pressurizing equipment to regulate the dry air supply for this RF system was provided with an ANDREW Type 1910 dehydrator.

This is just one of many ANDREW antenna system installations in Canada that are consistently giving optimum performance in UHF/VHF and microwave frequencies. To get all the facts on ANDREW antenna systems, write or call today, giving your specific requirements.

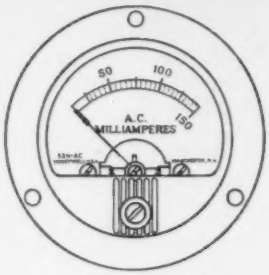


Andrew
ANTENNA
CORPORATION LTD.
606 Beech St. • Whitby, Ontario, Canada
Telephone: MOhawk 8-3348

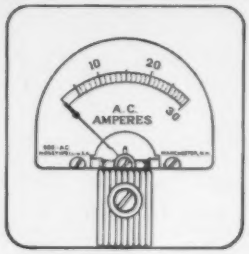
ANTENNAS • ANTENNA SYSTEMS • TRANSMISSION LINES

For further information mark No. 13 on Readers' Service Card

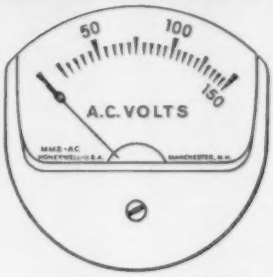
ANNOUNCING THE NEW HONEYWELL
IRON VANE AC
PANEL METERS



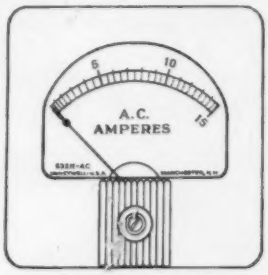
52N-AC 2 1/2"



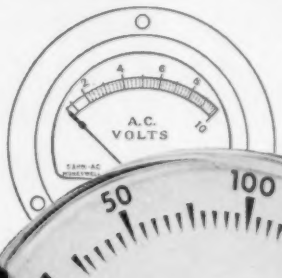
52S-AC 2 1/2"

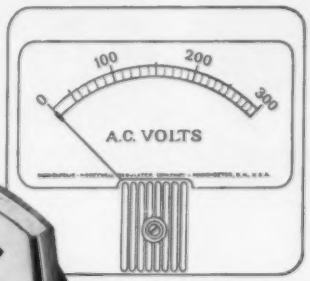


MM2-AC 2 1/2"

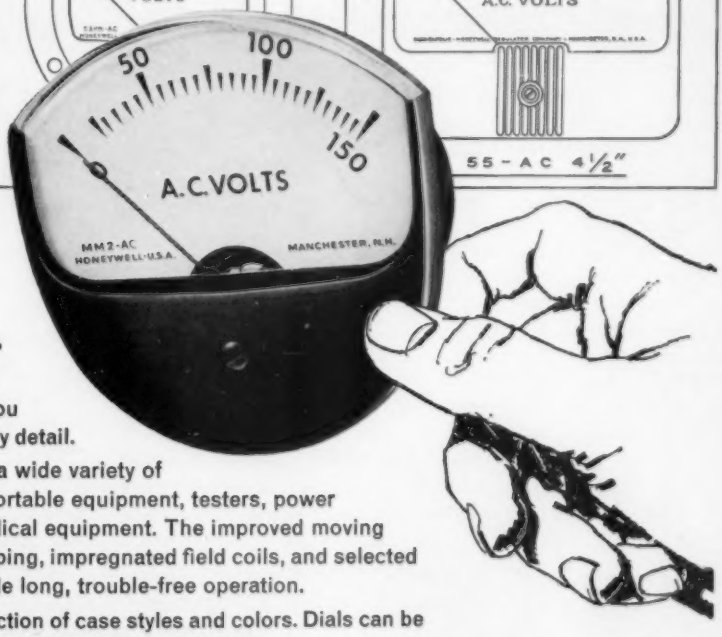


53SN-AC 3 1/2"





55-AC 4 1/2"



Here are the AC counterparts of Honeywell's popular DC panel meters. Iron Vane AC Meters are perfectly matched to the DC range and are available in both the Medalist and "standard" case styles. This means a minimum of trouble and expense in mounting. And you are assured of harmonious styling in every detail.

Iron Vane AC Meters are designed for a wide variety of commercial applications — including portable equipment, testers, power supplies, generator equipment and medical equipment. The improved moving iron mechanism features magnetic damping, impregnated field coils, and selected fixed and moving iron material to provide long, trouble-free operation.

These meters are available in a wide selection of case styles and colors. Dials can be custom designed with your company name, trade-mark or other data.

For full information, call your nearest Honeywell Office or write Honeywell Controls Limited, Precision Components Division, Toronto 17, Ontario.

Honeywell

H Precision Meters

For further information mark No. 40 on Readers' Service Card

integrated protection

for avionic systems

communications / navigation / fire control / countermeasure / flight control

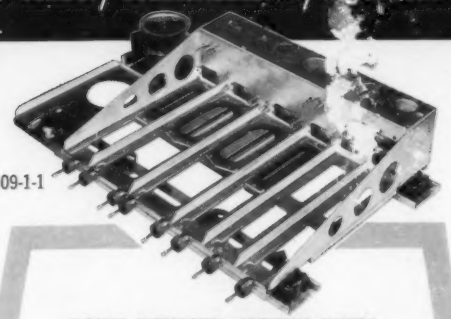
Get exactly what you need in an integrated mounting system by utilizing the special skills of Lord, the leader in vibration/shock/noise control. This move will assure all the benefits offered by consolidating your aerospace electronic system on one structural base.

The marriage of "black boxes" and protective structures is a highly developed Lord capability. This gives you *the most system for your money*—one that is lighter, smaller, more reliable, longer lasting.

Lord offers custom design and qualification testing plus construction of complete, integrated mounting systems. To meet your most rigid specifications, Lord has available such exclusive materials as:

BTR® Elastomeric Mountings—excellent all-attitude control of high-frequency vibration from —65° to +300°F.

Dyna-damp Structural Laminates—built-in damping provides a new approach to control of acoustic fatigue and structural response.



BL-1909-1-1

TYPICAL INTEGRATED MOUNTING SYSTEM

Performance Characteristics:

Application: navigational system for jet aircraft — four ¼ ATR units, two ⅜ ATR units, computer, blower. Weight: equipment — 51.7 lbs., base — 11 lbs. Shock/vibration protection: all-attitude — meets MIL-E-5272C plus sustained accelerations. System natural frequency: 25 cps vertical. Isolators: eight BTR Mountings, 10 lb. rating. Operating temperature range: —65° to +300°F. Cooling: provided for four units. Special hardware: tie-down clamps, locating pins, plenum chamber, seals, throttling orifices, provisions for electrical connectors.

RAILWAY & POWER Engineering Corporation, Limited

LORD®

For further information mark No. 52 on Readers' Service Card

Versatile programming

plug-in programming for each individual column, code options with plug-in column cards

Fast data transfer

takes just 2 msec; prints up to 5 lines per second

Flexible BCD input

1-2-2-4 BCD input is standard; dual input available

all yours with this new hp 562A SOLID STATE DIGITAL RECORDER

SPECIFICATIONS

Printing Rate: 5 lines/sec. maximum

Column Capacity: To 11 columns (12 available on special order)

Print Wheels: 12-position, 0 through 9, a minus and a blank (Many special character wheels available from stock)

Driving Source: Parallel-entry 4-line BCD, 1-2-2-4. Other codes available on plug-in cards. Source reference voltages establish "0" and "1" states, which may be as much as 100 v above or below ground. "1" state 4 to 75 v above "0" reference. Driving power approx. 30 μa into 270,000 ohms.

Print Command: ± pulse, 20 μsec or greater in width, 6 to 20 v.

Hold Signal: (Available for each data source) —7 v to + 15 v and + 15 v to —7 v.

Transfer Time: 2 msec

Paper Required: Standard 3" roll or folded

Line Spacing: Single or double, adjustable

Size: Cabinet, 20¾" x 12½" x 18½"; Rack, 19" x 10½" x 16⅞" deep behind panel.

Price: hp 562A (cabinet) or hp 562AR (rack mount) $1,600.00 to $2,200.00 depending on options. hp 580A Digital-Analog Converter, price on request.

New, solid state hp 562A Digital Recorder prints digital data on 3" paper as fast as 5 lines per second, each line containing up to 12 digits. The instrument incorporates a unique data storage unit for each digit column that allows the data source to transfer data to the recorder in just 2 milliseconds, after which the source is free to collect new data.

Besides the standard parallel-entry 4-line BCD code (1-2-2-4), you can easily use other 4-line codes just by substituting plug-in column cards. Ten-line code operation (without data storage feature) is also available with plug-in cards.

Further, hp 562A accepts dual input (optional) and prints data simultaneously from two unsynchronized sources. A "patch panel" permits programming these two separate, unsynchronous inputs (even if coded differently) in any manner. Combinations of plug-in column code cards and "patch panel" column programming give complete flexibility in both dual-source data acquisition and data print positioning.

Analog output for high-resolution strip chart and X-Y recording is available as an extra-cost built-in feature of the 562A or through the new hp 580A Digital-Analog Converter, a separate solid state, high-precision instrument.

Designed for use with solid state and vacuum tube counters, Model 562A is ideal for a wide variety of individual and system applications. Call your hp representative today.

HEWLETT-PACKARD COMPANY

1082L Page Mill Road, Palo Alto, California, U.S.A.
Cable "HEWPACK" · DAvenport 6-7000

Sales representatives in all principal areas

HEWLETT-PACKARD S.A.

Rue du Vieux Billard No. 1, Geneva, Switzerland
Cable "HEWPACKSA" Tel. No. (022) 26. 43. 36

For further information mark No. 39 on Readers' Service Card

NEW LOW-NULL MOTOR GENERATORS

NOW MADE IN CANADA BY DAYSTROM!

Daystrom has whittled the null output voltages of its Size 9 and 11 Motor Generators down to a slim 0.003 and 0.006 respectively. Signal to noise ratio gets a big boost up to 120:1 for Size 9 and 100:1 for Size 11. Linearity is within .25%. A wide range of gear ratios can be furnished.

Complete specifications with drawings and charts are yours for the asking. Other types and sizes of motor and motor generators are also available. And be sure to get complete details on our new synchro line.

For more information, call or write Daystrom Limited, 1480 Dundas Highway E., Cooksville, Ontario; 5430 Ferrier Street, Montreal 9, Quebec. A subsidiary of Daystrom, Incorporated.

CANADIAN PLANT—COOKSVILLE, ONT.

6135

DAYSTROM LIMITED

WORLD LEADERS IN MEASUREMENT AND CONTROL

For further information mark No. 28 on Readers' Service Card

a *Genie* at your command—

the CALL director

The 30-button CALL director helps secretaries handle more calls, streamlines office operation.

From Northern Electric comes a new-style genie . . . the CALL director telephone. It's the versatile virtuoso of modern business communications. To reach many inter-office extensions—just press a button. To hold a telephone conference—just press a button. To connect outside calls to others—just press a button. The CALL director is available with 12, 18 or 30 buttons and many features to save precious business time.

The CALL director telephone is another step forward in the science of business communications by Northern Electric, who design and manufacture most of Canada's telephones and related equipment.

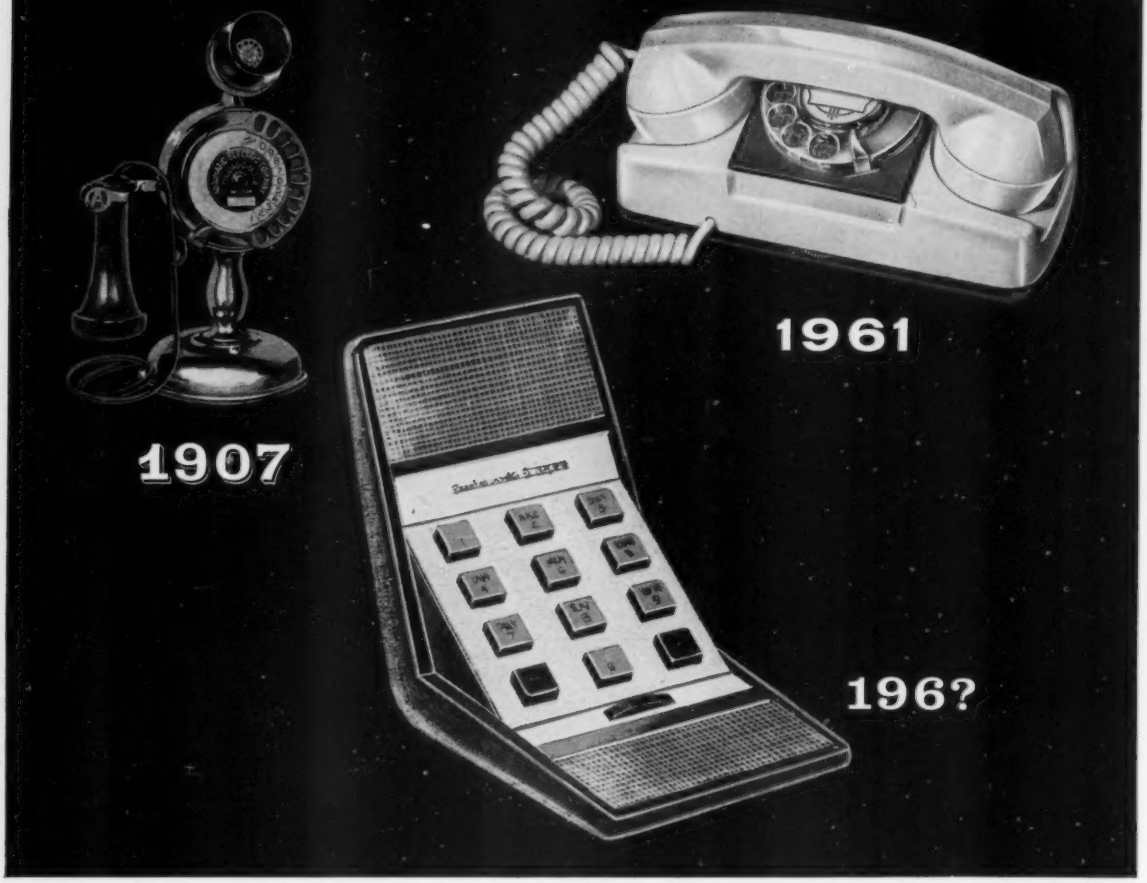
Northern's extensive experience in this field, along with their creative engineering and design personnel and modern manufacturing facilities are at your command. Branches are strategically located across Canada to serve you.

Northern Electric
COMPANY LIMITED

SERVES YOU BEST

2060-5

From Grandpa's day to the present . . . to the future . . . AUTOMATIC ELECTRIC leads the way in communications and control



Since the first large dial telephone systems in Canada were supplied by AUTOMATIC ELECTRIC over 50 years ago, AE has been a leader in every phase of telephone development. Today, the new Starlite extension phone is an example of the advance design thinking that goes into all new AUTOMATIC ELECTRIC products. Tomorrow, electronic switching equipment and telephones, now being engineered by AE, will be even more versatile. Manufacturing facilities in both Eastern and Western Canada and operations from coast to coast place AUTOMATIC ELECTRIC in the forefront of the Canadian communications industry. 6106

Over fifty years supplying Canadian industries and utilities with

- **EXPERIENCED ENGINEERING**
- **QUALITY PRODUCTS**
- **COMPLETE SERVICE**

AUTOMATIC ELECTRIC
Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

For further information mark No. 16 on Readers' Service Card

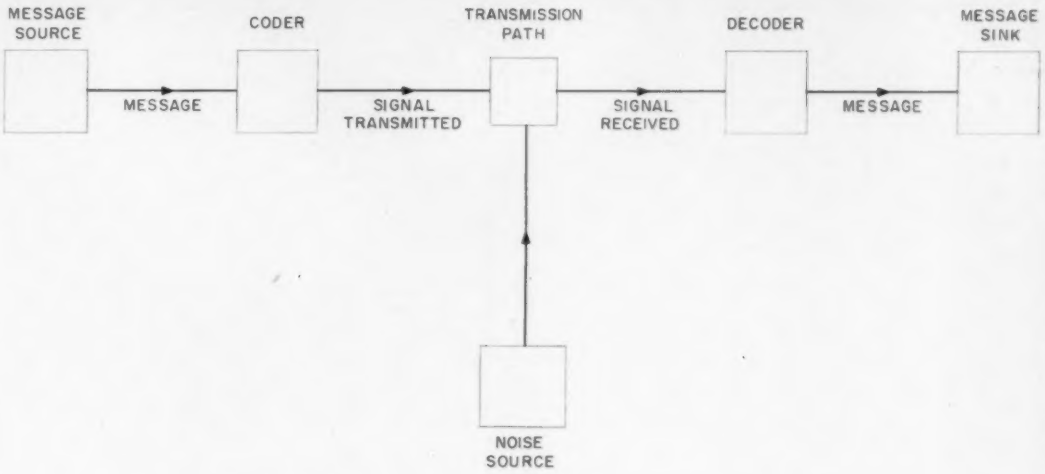


Fig. 1 Schematic diagram of a generalized communication system

Information theory paves way to new developments in communications

DOUGLAS A. CARRUTHERS, P.ENG.*

The subject of information theory is introduced by drawing attention to recent areas of specialization. Its association with communication and modulation theory and cybernetics is considered, followed by analysis of the generalized communication system and its practical relationship to information theory.

The development of information theory in the past decade has progressed very rapidly due to the efforts of a large number of skilled mathematicians and engineers. As expanded knowledge of this subject has been sought in a number of different directions the sheer breadth of the field now tends to be an obstacle to complete understanding by any one individual. Diversification has become evident in the literature where trends have developed toward specialization in some particular aspect of information theory. Basically the subject has been subdivided into the following five categories:

1. Basic Theory, for the mathematician interested primarily in the further development and extension of the subject;

2. Coding theory, of chief interest to the coding expert and the cryptographer;

3. Communication theory, for those engaged in the synthesis and analysis of communication systems;

4. Biophysical theory, for the biophysicist, the experimental psychologist; the neurophysiologist; and the specialist in human engineering;

5. Linguistic theory, which appeals to the semanticist, the comparative philologist and the researcher into the origins of language.

***Supervising Engineer, Data Communication Systems, The Bell Telephone Co. of Canada, Montreal.**

Analysis of communications systems

In the following presentation the application of information theory to the analysis of communications systems is considered. For those who prefer a quantitative approach to the basic problems of communication with the exclusion of such subjects as the electronics of communications, communication theory provides the closest approach to information theory. However, the term communications is of a general nature itself and is often identified with coding theory, modulation theory, and cybernetics.

Many books on modulation theory include several chapters on information theory and a number of books on information theory contain similar references to modulation theory. However, the terms information and modulation theory are not synonymous. Actually, modulation is not a part of information theory, but we use information theory to analyse it. The empirical development of the many practical modulation systems in use today has been based on certain parts of modulation theory with little reference to information theory. However these sys-

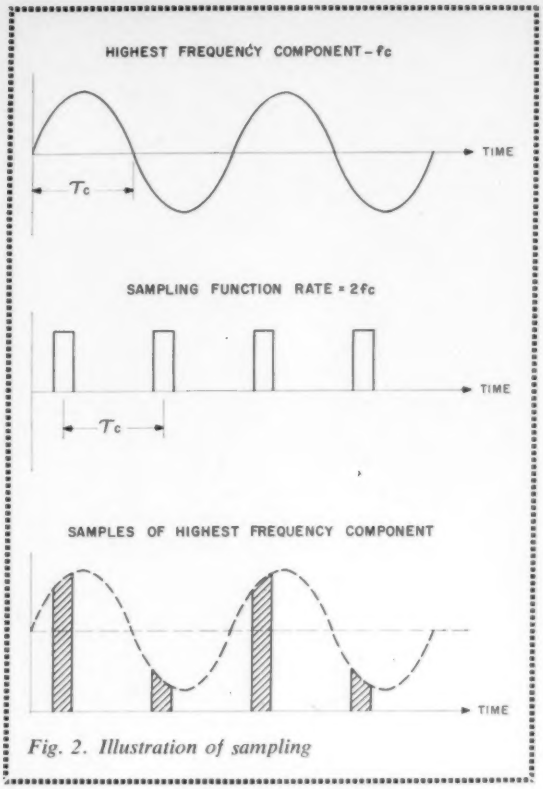


Fig. 2. Illustration of sampling

tems can now be justified (or condemned) in retrospect by quantitative analysis through information theory. Many of the new modulation techniques coming into use now or in the future actually will be derived from the fundamentals of information theory.

Cybernetics stresses the use of information to effect certain control actions rather than placing the emphasis on the measurement and transmission of information. The application of the cybernetics of electrical engineering to the control systems of living organisms or to certain mechanical - electrical systems such as computers, are both large topics in themselves and will not be covered in this article.

In analyzing a particular communications systems it is often helpful to refer to the generalized communication system (fig. 1) which is made up of the following five basic parts:

1. Message source;
2. Coder — to convert the message to a signal suitable for transmission;
3. Transmission path;
4. Decoder — to convert the signal to the necessary form for use at the receiving end;
5. Message sink.

The five major parts of the communication system have all been subject to exhaustive quantitative studies using information theory. The following section indicates in more detail how the theory is used to analyze each one of these parts.

1. Message source

In considering any message source our primary concern would be the average rate at which the source generates information. This rate, usually expressed in bits per second, is the information rate or entropy rate of the signal source. The entropy of a message source is proportional to the number of different combinations (messages) which that source can produce. Stated mathematically, entropy is:

$$H(x) = \sum_{r=1}^{r=m} Pr \log_2 Pr \quad \text{bits}$$

where Pr = probability of x = xr

xr = 1, 2, 3, ... m.

The word "entropy" is also the name of a mathematically related quantity used in thermodynamics and statistical mechanics. In thermodynamics, entropy is a measure of the disorganization of a physical system. Some physicists have expressed entropy as the negative of information.

The most important aspect of using information theory to study the message source of a communications system is the determination of the probability of occurrence for each code element and the subsequent derivation of the unpredictability or entropy of the message source. This value has real physical significance and is used in information theory analysis of other parts of the generalized communication system.

A typical example of the entropy rate of various message sources would be a comparison of the human rate with the machine rate of an electronic computer. The highest human information capacity as measured by psychologists is about 50 bits per second. Typical human reading rates range up to 30 bits per second. In these cases, the number of bits per word conveyed through a human being has been developed through probability theory as:

Log_2 n bits per word

where n is the number of words in the vocabulary with all words having an equal probability of being chosen.

A typical electronic computer can originate information on magnetic tape at up to 62,500 characters per second or 500,000 bits per second. This is about ten thousand times faster than any comparable human information rate.

2. Coder

Coding is a means of expressing information in a form suitable for use in some transmission system. Generally it is the translation from message to signal where message denotes the information in the original form and signal denotes the waveform which is transmitted over the communication channel.

Coding is of great interest to communications as it has recently been illustrated that a signal can be encoded in such a way as to reduce the bandwidths needed to transmit it. For example if we use a code which makes use of pulses of four possible amplitudes, twice as much information can be sent per pulse as compared to a scheme which makes use of two-value pulses (binary pulses). Thus, for a given transmission rate, we need send elements of the four-value pulses only half as frequently as was necessary for the two-value pulses and we therefore require only half as much bandwidth.

The disadvantage in using a code composed of multilevel pulses instead of binary pulses is an increased susceptibility to noise and amplitude level variations in the transmission medium. This is particularly evident in amplitude and frequency modulation where a reduction in bandwidth requires a greater margin over noise for the coded signal. Some phase modulated data systems do use the four-level pulse to advantage in doubling the information rate in a given bandwidth, while still retaining an error rate equivalent to an FM system using binary pulses.

Since 1957 there has been considerable progress in the theory of coding messages for transmission over noisy channels. The main advances have been achieved by a

substantial mathematical foundation for the theory, an error correcting block code for noisy binary channels and a continuing investigation of procedures in which input messages are coded and decoded sequentially rather than in long blocks. It is significant to note that a great deal of the accomplishment in these fields has resulted from the joint efforts of mathematicians and communications research workers.

Although error-correcting block codes have not as yet been used in digital communication systems, other coding techniques such as pulse code modulation (PCM) have been applied to both voice and television messages to improve transmission over facilities having a poor signal to noise ratio.

In order to code voice or television information efficiently, a conversion must take place from the original analog type of message to a digital signal of some sort. The first step in the process is to sample the original message at a periodic rate equal to twice the highest frequency component in the finite band of the message or modulating function. Oliver, Pierce and Shannon have proved that if the highest frequency component in the channel is fc cycles per second, the time function need not assume more than 2fc independent values per second. For this reason the amplitudes at any set of points in time spaced τc seconds apart, where $\tau c = \frac{1}{2fc}$, specify the message completely (Fig. 2). Hence to transmit a band-limited message of duration T, the entire continuous function of time need not be sent. It suffices to send the finite set of 2fcT independent values obtained by sampling the instantaneous amplitude of the signal at a regular rate of 2fc samples per second.

At the receiving end the sampled pulses of varying amplitude are restored easily to the continuous time function. The impulses appearing at the rate of 2fc per second are passed through an ideal low pass filter of cut-off fc. Except for an over-all time delay and possibly a constant of proportionality, the output of this filter will be identical to the original message.

The application of the sampling theorem has reduced the problem of converting an analog (continuously varying) message to one of converting a finite number of amplitude values to a digital signal code. In doing this we must limit ourselves to discrete amplitudes of the sample rather than attempting the impossible task of transmitting the exact value of a sample, which may have an infinite number of possible amplitudes.

Repeating the signal in this fashion by certain discrete selected levels only is called quantizing and is illustrated in Fig. 3. As might be expected this scheme introduces error, as the amplitude of the received samples will conform to one of the discrete levels and not to the exact original level. This results in an interfering effect known as quantizing noise. The noise can be reduced by quantizing the sample to a greater number of discrete levels. For example if four levels are used instead of two levels the quantizing noise would be reduced considerably. It turns out that a high-quality voice signal must be represented by 128 distinct amplitude levels in order to reduce the quantizing noise to an acceptable level.

It has been indicated previously that binary digits or two-state pulses are the least susceptible to noise or other interference, although more band-width is required. In the 24-voice channel pulse code modulation system on trial in the Bell System, each of the 128 amplitude levels is coded by means of a specific binary code group. From Hartley's work it is known that a group of n binary pulses can represent a total of 2^n different amplitude levels. In order to represent any one out of the 128 possible levels

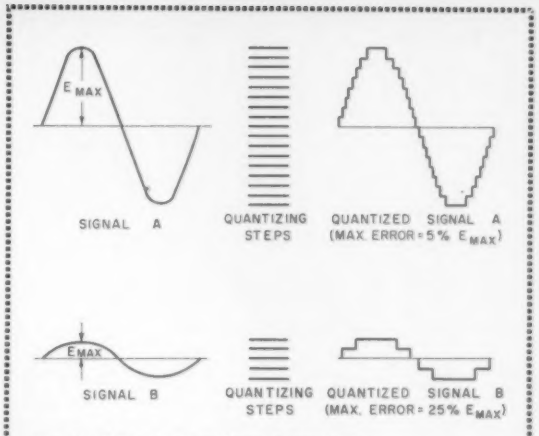


Fig. 3. Effects of uniform quantizing

by a pulse group, that group would require:

$2^n = 128$

n = 7 pulses

Thus the coder for the pulse code modulation system cited as an example converts the original voice message samples to a series of seven-bit codes which occur at a repetition rate equal to 2fc. For the voice channel the maximum frequency fc would be 4,000 cycles per second. Hence the binary code repetition rate is 8,000 times per second. Table I provides a partial list of the coding that could be used for this application.

Table I

PCM binary coding

Amplitude level of sample (128 possible levels)	**Code** (7 bit characters)
0	0000000
1	0000001
2	0000010
3	0000011
4	0000100
5	0000101
6	0000110
7	0000111
8	0001000
9	0001001
10	0001010
11	0001011
..	....
..	....
126	1111110
127	1111111

3. Transmission path

In considering signalling speeds and the information capacity of a transmission path, it is necessary to take into account two important factors: bandwidth and noise.

Considering bandwidth, Nyquist's theorem states that the maximum signalling speed under ideal conditions is two code elements per cycle of bandwidth.

That is

$C = 2f$

where C = number of impulses per second

f = cut off frequency of the transmission system in cycles per second

In most applications, signalling speed is expressed in bits per second. To convert code elements to bits, one

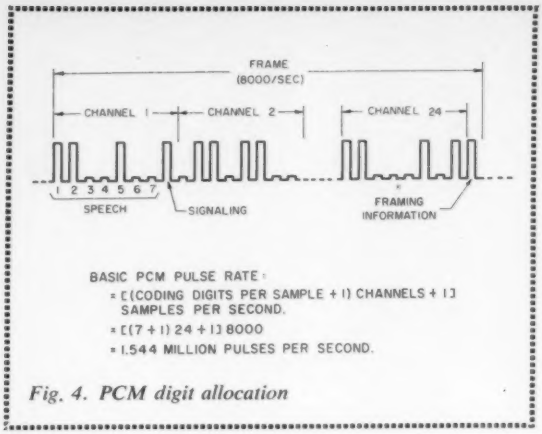


Fig. 4. PCM digit allocation

has to realize that the information content of a code element is ($\log_b$ b) bits where b is the base of the signalling system (binary, ternary, quarternary, etc.). Therefore in bits per second the maximum information capacity is:

$$C = 2f \log_b$$

In the application of the Nyquist theorem for maximum signalling speed over a band-limited channel, it is evident that the transmission speed in bits per second is proportional to $\log_2$ b. As pointed out earlier, a code using a higher base system to increase the channel capacity increases the susceptibility of the system to noise and other disturbances, particularly for amplitude and frequency modulated schemes. Nyquist's theory stipulates the transmission speed for an ideal or noiseless channel only.

Shannon has carried this concept further by showing that the maximum channel capacity C in bits per second is a function of both bandwidth and the noise present in the channel.

$$C = W \log_2 (1 + S/N)$$

where W = bandwidth of channel in cps
S = average signal power
N = white or thermal noise power.

This maximum capacity assumes that ideal coding and modulation methods used. Any speed of transmission exceeding this channel capacity will result in errors. Two channels having the same "C" have the same capacity for transmitting information, even though the quantities W, S, and N may be different.

The equation does not specify how such an ideal coding of the message may be realized and in any practical system there will be a finite probability of error for a finite transmission rate. Of greatest interest in Shannon's result is the fact that bandwidth can be traded logarithmically with signal-to-noise ratio for a fixed rate of information transmission.

Another interesting conclusion based on Shannon's formula is the fact that the increase in bandwidth results in a greater increase of channel capacity than a corresponding increase in signal power. Bandwidth W is a linear function of C. The logarithmic function will produce a smaller change in C than the linear function. Consequently, in a particular system, it is more beneficial to increase the bandwidth than the signal power to achieve a greater transmission capacity. This is the approach taken in frequency modulated systems and more recently in pulse code and pulse position modulation schemes.

Two parameters of information theory which have real physical significance have now been introduced. These are "H", the entropy rate of the source and "C" the information capacity of the noisy channel. Study of information theory has led to an important relationship connecting H and C. If H is less than C, there exists a transmitter and receiver such that the messages produced by the source can be delivered over the channel to a destination with an arbitrarily small error rate. If H is greater than C, there is no possible way of transmitting the messages from the source over the channel to a destination without a certain fixed finite rate of errors.

Reverting to our pulse code modulation example to illustrate how the information theory may be applied, we recall that there will be one seven-bit binary code transmitted for each voice sample and that the entropy rate will be at the rate of 8000 samples per second. Actually this particular system transmits an eight-bit code with the eighth bit used for supervisory and signalling requirements. Since we wish to transmit up to 24 simultaneous voice circuits using time division multiplex over the PCM system, the channel capacity required in bits per second is 1.544 million, as derived in Fig. 4. This includes one bit per 24 channel group for framing (synchronization).

From Nyquist, the nominal bandwidth required for 1.5 million bits per second is 750 kc. This is about eight times the 96 kc bandwidth required for the single sideband transmission of 24 channels.

Using Shannon's theorem, the signal to noise requirement S/N may be determined for:

$$C = 1.544 \times 10^6 \text{ bits per second}$$
$$W = 7.50 \times 10^5 \text{ cycles per second}$$
$$C = W \log_2 (1 + S/N)$$
$$\log_2 (1 + S/N) = C/W = 2$$
$$1 + S/N = 2^2$$
$$S/N = 3$$
$$10 \log S/N = 5 \text{ db}$$

Since Shannon's equation is independent of coding and modulation methods, the signal-to-noise ratio calculated will be for an ideal system. Laboratory tests indicate that for an error probability of 10^{-6} (which is close to perfection) the binary PCM technique for voice message transmission requires a signal-to-noise ratio about 12 db better than Shannon's theoretical value. With a typical amplitude modulated system having a comparable error probability, a signal-to-noise ratio about 30 db better than Shannon's ideal would be needed.

4. Decoder

The process of reception and interpretation can be called decoding, because it consists of working back from the received signal or apparent code group to that message which is most likely to have been coded into the signal in question. In considering an ideally coded message it is not at all obvious how in an electrical system one carries out the process of decoding. The salient requirements from Shannon's work are that the received signal shall be treated as a whole (not digit by digit) and that there must be an act of recognition, that is of equating the received signal to some particular one of the set of possible transmitted messages. This implies the availability at the receiver of a set of replicas of all possible messages, against which the received signal can be compared. It has been found that the advantage to be gained from a system of coding and decoding approximating Shannon's ideal is not very great when compared with the complexity of apparatus that is required. A digit-by-digit decoder involves only a modest sacrifice of communication speed or increase in signal power.

5. Message sink

An obvious requirement for the message sink is that it must have the capacity for accepting information at a rate equal to or greater than that prevailing over the re-

mainder of the system. Generally information theory analysis of the sink is connected directly with a study of the source entropy rate, especially if sink and source have identical characteristics.

The traditional communication systems are characterized by the fact that the source and sink are human rather than machine. The names telegraph, telephone and television indicates a means of extending the range of human senses. The important thing to remember is that the human brain undertakes a part of the encoding and decoding operation. In fact a spoken language may be regarded from this point of view as a form of encoding developed through evolution to meet the needs of human communication. It is common experience that when confronted with severe interference, man speaks more slowly and uses a smaller vocabulary. This is equivalent to a reduction in the rate of information transmission. Hence the human adjusts the form of the encoding intuitively to suit the characteristics of the communication channel. In a similar fashion the human brain also undertakes the critical decoding operation, varying the degree with the type and severity of circumstances.

Machine to machine communication is a comparative newcomer to the traditional forms of communication. Data communication, which identifies this new service, does not benefit from the advantages of the human brain to undertake complex encoding and decoding operations. As a result, information theory must be developed and applied to the encoding, transmission, and decoding of data messages to compensate for the lack of the human power to adjust.

In addition to this problem there is an increasing demand for communication facilities to transmit data at higher and higher information rates. The theory must be relied upon again to come up with coding methods which will conserve bandwidth and operate in the presence of noise.

Improving channel capacity

As digital technology and manufacturing techniques are progressing very rapidly, one can see that the cost of communication terminal equipment will likely decrease in the future. On the other hand, the cost per unit of providing the communication facility itself will not change appreciably. This suggests a trend toward a more efficient utilization of channel capacity using techniques developed through information theory at the expense of more complicated terminal equipment. A practical example of this is the TASI (Time Assignment Speech Interpolation) system.

The TASI system was developed for use with extremely expensive communication facilities such as long submarine cables. The principle of this system, developed through information theory, is based on the fact that in voice messages there exists a certain percentage of time (about 60%) when the talker is not using his communication channel. This occurs during speech pauses or while listening. In order to increase the rate of transmitting information over expensive 4-wire submarine cable facilities, a complex terminal was developed which will switch very rapidly, a talker who has become active to a channel previously occupied by a talker who has become inactive. This can be done if two or three dozen telephone channels are operated as a group to serve two or three times as many talkers. This is an example of the use of information theory to increase the efficiency of transmission on a communication system.

TASI is an operational system at the present time but does not represent the ultimate in information transmission. A further application of information theory can be found in the field of bandwidth reduction for normal voice transmission.

If the maximum human information rate, developed previously at 50 bits per second, is transmitted over a toll quality channel with a signal-to-noise ratio of 30 db, the bandwidth requirement, assuming optimum coding, is determined from Shannon's relationship as:

$$W = \frac{C}{\log_2 (1 + S/N)}$$

$$= \frac{50}{\log_2 (1 + 1000)}$$

$$= \frac{50}{10}$$

$$= 5 \text{ cycles per second}$$

With no coding scheme, the toll quality telephone channel must provide a bandwidth of at least 3 kc for acceptable transmission. This demonstrates the high degree of information redundancy present in vocal communication.

Development of the Vocoder

Of the various efforts to improve the coding efficiency of speech the one that has probably achieved the greatest success is the Vocoder. Various information theorists have pointed out that although the speech wave has a highly complex waveform arising from its numerous harmonic frequencies whose phases are not related simply, it carries information only by virtue of its slowly changing energy-frequency pattern. This can be displayed graphically on sound spectrograms. The speech therefore can be transmitted in any convenient manner provided that this vital characteristic is preserved. The Vocoder invented by H. B. Dudley passes the speech through a bank of sixteen contiguous band pass filters, rectifiers and low pass filters which produce corresponding signals indicating the fluctuations of energy in each pass band.

Since each of the energy signals varies at a slow rate, each can be limited to a band of about 20 cps. Utilizing a group of single sideband channels, these signals can be transmitted over a total band of approximately 320 cps. The signal-to-noise ratio required is about the same as for the uncoded speech channel.

At the receiving terminal, the output of an impulse generator, simulating the vocal chords, or a noise source simulating the voiceless energy in sounds such as "sh", is passed through a bank of filters identical to those at the transmitting terminal. The amplitude of the output signal from each filter is controlled by the low frequency energy signal derived from the corresponding transmitting filter. The controlled outputs from the receiver filters are added to create a signal whose energy spectrum is a close approximation to the original speech. A switching voltage selects the appropriate artificial vocal source (impulse or noise generator). In order that the reconstructed speech will have the required quality, it is necessary to synchronize the vocal chord simulator with the pitch frequency of the original speech, thereby retaining the talker's inflection. This is accomplished by deriving a low-frequency signal whose amplitude is proportional to the voice pitch. Both the switching voltage and the pitch control voltage can be sent over one additional 20-cps channel.

Thus the original speech energy has been compressed from 3-kc to seventeen 20-cps channels. The total compressed bandwidth is 340 cps which represents a reduction of 10 to 1. Further development in this field may achieve even more efficient use of the voice spectrum.

Vocoder and similar devices have not, as yet, been utilized in the telephone systems, principally because speech processing of this type degrades the quality of the speech transmitted. Present research in the speech coding field is directed toward reducing such degradation so that ac-

ceptable speech quality can be achieved. Vocoders developed through information theory may enable telephone systems to utilize existing transmission channels more efficiently in the future.

Video transmission

The bandwidths required for television transmission are generally very large and expensive. Efficient utilization of the channel in this case is of considerable importance. In this type of communication system, the end result is a picture seen by the human viewer. The principle requirement is that the received television signal contain enough information to satisfy the subjective needs of the viewer. The needs cover such items as perception of sharpness, tone rendering, contrast, freedom from extraneous patterns or other interference and color rendition in the case of color TV systems. In the past, it has been difficult to measure these subjective perceptions in terms of information content. However, it has been found that the techniques of information theory can be quite helpful in the engineering of video transmission systems.

Since the urgent problem is to provide a cheaper video channel, several approaches have been made through information theory to provide a signal requiring a reduced bandwidth. The first approach was to determine the possibility of increasing the signal power in exchange for narrower bandwidth. However a study of Shannon's theory shows that this trade would not generally be favorable. The second approach is to consider a coding scheme which approaches more closely the ideal. The number of intensity levels which can be distinguished simultaneously on a cathode ray tube is not large, so that in theory, the signal amplitude should be capable of quantization in a few levels. In fact, quantizing with as few as 32 levels has been used in an experimental pulse code modulation system where each quantized amplitude is represented by five binary digits. With the pulse code system, however, the advantage is improved performance on noisy channels rather than reduced bandwidths.

With the increased development of information theory as a mathematical tool, there have been a number of recent proposals made for reducing the inefficiency of monochrome television. One of the methods is to separate the high frequency from the low frequency components of the signal and convert each to a separate digital signal. The low frequency digits, which occur less frequently (but are the more important), are transmitted with customary accuracy. The high frequency digits, which occur at a high rate are translated on a very coarse scale of quantized graduations. An experimental system of this type requires a frequency band for the digital transmission which is about half of that required for the present modulation scheme.

Color television

The National Television Systems Committee (NTSC) standard for color television broadcast signals, adopted by the Federal Communications Commission, has also made use of conclusions derived through information theory. In this case it was desired to use the existing monochromatic network for color transmission through more efficient use of the frequency space. It was discovered that the human eye, in resolving image detail, appreciates chromatic information less than it does luminance information. In addition, it needs less chromatic information for certain colors than for others. Thus, a color television signal can be divided into one luminance signal and two chromatic signals, with the luminance signal requiring the widest bandwidth; one chromatic signal will require a wider bandwidth than the other. In effect, the two chromatic channels are multiplexed on the luminance channel by interleaving them in the same frequency space.

In this manner the same frequency space as used for a monochrome television signal is made to carry more information for the color television signal. The extra information has been tailored, as far as possible, to meet the subjective needs of the ultimate viewer and has been inserted in portions of the original signal band which contain little information content.

The problem of providing increased efficiency in television transmission while improving performance over noisy channels still provides a challenge to the mathematicians and will be the subject of many future studies using the techniques of information theory.

There is little doubt in the minds of the communications engineers as to the importance of information theory to present day communication technology. As research workers dig deeper into the realm of information theory it is expected that this subject will play a role of more and more importance in practical communication systems of the future. END

BIBLIOGRAPHY:

1. H. Nyquist, "Certain Factors Affecting Telegraph Speed," Bell System Technical Journal, Vol. 3, April, 1924, pp. 324-346.

2. H. Nyquist, "Certain Topics in Telegraph Transmission Theory," AIEE Transactions, Vol. 47, April, 1928, pp. 617-644.

3. R. V. L. Hartley, "Transmission of Information," Bell System Technical Journal, Vol. 7, July, 1928, pp. 535-563.

4. C. E. Shannon, "A Mathematical Theory of Communication," Bell System Technical Journal, Vol. 27, July, 1948, pp. 379-423, Oct., 1948, pp. 623-656.

5. B. M. Oliver, J. R. Pierce, C. E. Shannon, "The Philosophy of PCM," Proc. IRE, Vol. 36, Nov., 1948, pp. 1324-1331.

6. C. E. Shannon, "Communication in the Presence of Noise," Proc. IRE, Vol. 37, Jan., 1949, pp. 10-21.

7. F. L. Stumpers, "A Bibliography of Information Theory - Communication Theory - Cybernetics," Transactions: Professional Group on Information Theory, IRE, Nov., 1953.

8. C. E. Shannon, "The Rate of Approach to Ideal Coding," IRE Convention Record, Pt. 4, 1955, p. 47.

9. C. E. Shannon, "Some Results in Coding Theory," IRE, Convention Record, Pt. 4, 1956 p. 126.

10. D. A. Bell, "Information Theory and its Engineering Applications," Pitman, 1956.

11. W. T. Rea, "The Communication Engineer's Needs in Information Theory," AIEE Transactions Jan., 1957, pp. 805-808.

12. J. R. Pierce, J. E. Karlin, "Reading Rates and the Information Rate of a Human Channel," Bell System Technical Journal, Vol. 36, March, 1957, pp. 497-516.

13. P. Mertz, "Information Theory Impact on Modern Communications," AIEE Transactions, Sept., 1957, pp. 431-437.

14. R. Filipowski, "Recent Progress in Applying Information Theory to Digital Transmission Systems," AIEE Transactions, Jan., 1959, pp. 848-855.

15. K. Bullington, J. R. Fraser, "Engineering Aspects of TASI," Bell System Technical Journal, Vol. 38, March, 1959, pp. 353-364.

16. J. R. Simpson, "Data and its Transmission," Canadian Electronics Engineering, July, 1960.

17. R. M. Fano, "Transmission of Information," MIT and John Wiley, New York, 1961.

18. P. Elias, A. Gill, R. Price et al, "Progress in Information Theory in the USA, 1957-1960," Professional Group on Information Theory, IRE, July, 1961.

Fig. 1. Ken Harbinson, chief operator at CFRB-FM, has all his stereophonic control and reproduction equipment within easy reach. In the adjoining booth, announcers can broadcast "live" or prepare cartridge tapes for later use.

How CFRB-FM built its stereo system

CLIVE EASTWOOD, MEM. IRE.*

Anticipating the advent of stereophonic broadcasting in Canada, CFRB began planning and practising in 1959. When authorization was granted on September 1, 1961, CFRB-FM was ready for the new medium. This account of their equipment and experiences will help others entering the field.

At CFRB we had been doing AM/FM stereo broadcasting from November 1959 to January 1961, at which time the Department of Transport wrote all stations prohibiting this type of stereophonic broadcasting. This period gave us experience in studio reproduction problems, and a start on a stereo library at the station.

The record companies helped us build the stereo library by releasing stereo discs before their monophonic counterparts. To play them we used a Fairchild SM-1 stereo cartridge with the left and right outputs in parallel to provide a sum signal. These cartridges have 0.7-mil stylii which have given improved quality on our monophonic 45's and LP's.

At the October, 1960 meeting of the Board of Broadcast Governors, CFRB applied for permission to start separate FM programming, and to increase from 0.3 kw at 50' above average ground to 200 kw at 441' above ground. The power increase was granted in January but it was not until April of 1961, after several rehearings, that permission to proceed with separate FM programs was given. By that time standards for FM stereophonic broadcasting had been announced for the United States. We assumed that standards would be set for Canada before the end of the year and made provision for stereo wherever possible.

We went on the air with our new studio and transmitting plants on July 1 of this year. Canadian stereo standards for FM broadcasting were issued on August 4 and were made effective September 1, at which time CFRB-FM went on the air with stereo.

Much of our equipment has been modified or adapted in various ways to fit into our stereo system. Stereophonic broadcasting is so new that commercial equipment was not readily available when we were putting our system together. A description of our equipment and experiences may be of value to others planning similar installations.

Studio equipment

The console used is shown in Fig. 1. It is a McCurdy SS4600, twelve-input, two-channel console with three subchannels. Note the special knobs which gang two faders together to form stereo pairs. This is a left-right console

*Chief Engineer, Rogers Radio Broadcasting Co. Ltd., Toronto. (CFRB and CFRB-FM)
Based on a paper presented to the 10th Annual CCBA Engineering Conference, Toronto, October, 1961.

Fig. 2 *Fig. 3* *Fig. 4* *Fig. 5*

Fig. 6 *Fig. 7* *Fig. 8* *Fig. 9*

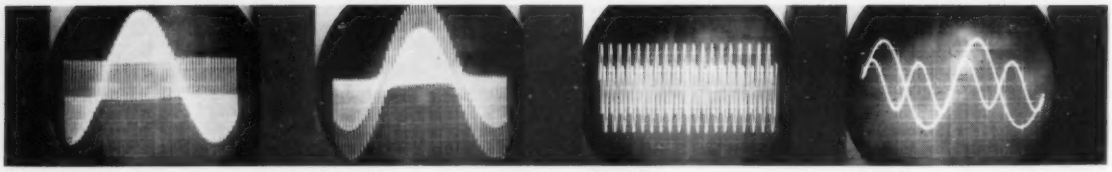


Fig. 10 *Fig. 11* *Fig. 12* *Fig. 13*

as it is used for the **reproduction** of records, tapes and cartridges. A **production** console for original recordings or broadcasts should be of the sum-and-difference type for greater flexibility.

To the right of the operator are a pair of Northern Electric R20643A stereo turntables. On his left are three racks. No. 1 rack, on the extreme left, is associated with the console; No. 2 contains an Ampex 350-2U stereo reel tape machine, and has space for another tape; No. 3 contains an RCA RT-21 stereo reel tape, two RCA cartridge tape machines, the FM studio switching control panel and an FM transmitter control panel. The transmitter is unattended and can be controlled from any of 3 locations at the studio. When in "stereo", the studio switcher feeds separate L and R signals down 2 pairs of lines. When in the monophonic mode, only the left line is used, with the studio switcher adding the left and right outputs from the stereo studio.

The FM stereophonic system

Now let us take a look at the theory of the FM stereophonic system. The formal requirements are set forth in the Department of Transport's Broadcasting Procedure 6 (see page 44); Procedure 7 sets out the rules for Subsidiary Communication Multiplex Operation.

For stereophonic broadcasting, three signals are used. The first is designed to make the stereo broadcasts compatible for listeners with monophonic receivers; it consists of the left and right audio signals added together in a matrix unit and fed into the normal input of the FM transmitter. This covers the audio frequency range from 50 - 15,000 cps and is all that is heard from a mono FM receiver. This signal modulates the transmitter up to 90%, which is + and — 67.5 kc deviation of the carrier frequency from the nominal centre frequency.

The second signal is a synchronizing signal called a pilot tone. It is usually crystal controlled at 19 kc and modulates the transmitter 10% to cause a swing of + and —7.5 kc.

The third signal contains the stereo information. It deviates the main carrier to a maximum of 90% deviation just the same as the L+R sum signal does. However, it is arranged so that the total modulation of these two signals never exceeds 90% at any instant. This third signal has components in the frequency range of 23 -53 kc, which are the sidebands of a double-sideband amplitude-modulated signal having a suppressed 38kc carrier. If you keep in mind that these sideband signals cause FM deviation of the main carrier, just as the main channel input and pilot tone cause main carrier deviation, it will help when working with this system.

The signal that causes the amplitude modulation is an audio signal which represents the difference between the left and right signals and is the second output of the matrix. Since amplitude modulation is a linear process the amplitude of the L-R signal causes a proportional deviation of the main carrier frequency through the medium of the proportional AM sidebands that are generated. At the receiver, the detected L + R and L — R signals can be matrixed back to L and R.

To illustrate how the sum and difference signals may each cause 90% modulation swing of the main carrier without overmodulation, assume a 400 cps "Left" signal of 1 volt causing 90% total modulation; this will consist of 45 modulation at 400 cps, 22.4% at 38,400 cps and 22.5% at 37,600 cps. If a 400 cps "Right" signal in phase with the "Left" signal is gradually increased also to 1 volt, then the L + R signal will increase to 2 volts for 90% modulation at 400 cps while the L — R signal will decrease to 0 for zero modulation due to the 38 kc sidebands.

As can be seen, an L only, or an R only signal is transmitted equally by both the main channel and the subcarrier channel. To maintain the required 30 db separation between left and right channels, the variations between channels must be less than 0.3 db in level and 3 degrees in phase at each frequency over the range of 50 - 15,000 cps. At 15 kc, 3 degrees is approximately 0.5 usec in time. Amplifiers within 0.5 db over this frequency range are considered excellent; however, when two are paired in sum and difference stereo channels this gives a 1.0 db tolerance which is 3 times the allowable tolerance. Perhaps the manufacturers will specify a curve for their audio

amplifiers and be able to guarantee + or —0.1 db tolerance to that curve, rather than the current specification of + or —1.0 db referenced to 1000 cps. The relative phases would also have to be specified.

From this, it can be seen why the line companies have stated that they cannot network stereo programs at the present state of the art. Stereophonic broadcasting will probably be entirely local in origin for some time.

Typical waveforms

To give some idea of the form of the signals discussed, pictures were taken on an oscilloscope bridged across the ratio detector output of a wide-band monitor (G. E. BM1A FM frequency and modulation monitor). This point is also the input of any stereophonic detector (adapter) which selects the 3 signals and operates on them to recover Left and Right.

Figure 2 shows one cycle of a 400 cps audio signal that had been fed into the normal input of the transmitter. The L + R output of the matrix unit normally feeds this input. For the picture, the pilot was cut off.

Figure 3 is similar to 2, but with the pilot tone or synchronizing signal turned on.

Figure 4 was taken with 400 cps into the L — R, or subcarrier generator input, with the pilot off. The series of cups at double the audio frequency is characteristic of a suppressed carrier signal.

Figure 5 has the pilot tone added, which displaces every other cycle of the 38 kc.

Figure 6 is more normal than any of the previous signals shown. It is a 400 cps "Left" only signal with pilot tone. See how the 38 kc sideband (L - R) portion fits between the zero voltage baseline and each half of the L + R signal cycle. Note two points: the pilot tone causes an equal deviation of the 38 kc carrier above (or below) the envelope and below (or above) the baseline; the baseline is straight. Later figures will show variations on these two points and their significance will be discussed.

Look carefully for differences between Figures 6 (Left only) and 7 (Right only). There are none!

Because of this, it cannot be determined whether a Right or Left signal is being broadcast; hence, for the first two weeks at CFRB-FM we had the Left and Right channels interchanged so that the orchestras were hanging upside down from an inverted floor, so to speak. Shifting the phase of the pilot tone by + or — 90 degrees creates the same composite waveform as these two figures show. However, the resultant 180 degree shift in the 38 kc obtained at all receivers causes the Left and Right outputs to be interchanged.

There seem to be three ways of telling whether left is left or right, and the first two are pragmatic:

(a) believe Bill Miller, Chief Engineer of Canadian Admiral. (He had been monitoring CFRB-FM stereo broadcasts on laboratory equipment at Canadian Admiral and concluded the channels were interchanged);

(b) assume that your monitor receiver is correct if it has Left and Right labels. (Ours had "A" and "B" labels);

(c) temporarily add a 45 degree phase shift to the pilot tone and see whether the base line or the envelope flattens out. A positive phase shift and a left signal will have a flat base line[1].

Figure 8 shows a Right only signal as before, but with too much gain in the L - R channel causing too much subcarrier modulation.

Figure 9 shows too little L - R gain. You can see that a flat baseline indicates proper modulation levels.

Figure 10 shows a Right only signal with the pilot phase advanced 45 degrees to obtain a smooth envelope curve. Compare it with Figure 11 which has the phase retarded 45 degrees to obtain a smooth baseline. These "smooth" lines are not as smooth as they should be because of 19 kc pilot tone leaking into the carrier output within our subcarrier generator.

Figure 12 was taken using both traces of the oscilloscope and a sweep rate of 100 usec/cm. The larger trace is the 19 kc pilot from the sub-carrier generator; the smaller trace is the 38 kc signal from the subcarrier generator when it was unsuppressed and with no modulation.

Figure 13 is the same as 12, except that the sweep rate has been increased to 10 usec/cm. Note that the signals cross the zero voltage axis together, and at the centre of the trace they are both going positive together. This indicates that there is negligible phase delay between the generator and the detected output from the monitor. It illustrates the waveform relationship specified by the Department of Transport (see 3(c), page 44).

The FM broadcasting system we use is an amazing one. It can reproduce sound with excellent fidelity; one of the most impressive experiences is the dead silence which exists between selections. This system, which was designed to carry frequencies up to 15 kc, is transmitting two closely matched channels using frequency components up to 53 kc. It can also carry several additional unrelated program services.

Stereo broadcasting is just getting under way and pioneering stations have had to improvise due to lack of equipment on the market. I expect that simple, reliable stereo generators and monitors will be available soon. Meanwhile, this account of our experiences at CFRB-FM may be of some assistance to other broadcasters setting up stereo facilities. END

REFERENCE:

1. A. Csicsatka and R. M. Linz, "The New Stereo FM Boadcasting System — How to Understand the FCC Specifications and Generate the Composite Signal," Audio Engineering Society preprint No. 195.

A number of other papers on the subject of stereo boadcasting were presented at the 13th Annual Meeting of the Audio Engineering Society, New York, October 9 - 13, 1961. A list of those available in preprint form is given below. Copies may be ordered from the Society (Box 12, Old Chelsea Station, New York 11, N.Y.) at 50 cents each for members, or 85 cents each for non-members.

F. K. Becker, Criteria for Compatible AM-FM Stereo as an Interim Method For Compatible Multiplex Stereo."

R. W. Burden and S. E. Frohock, "Audio Considerations For Stereophonic Broadcasting."

D. R. von Recklinghausen, "Multiplex Stereo FM Tuners and Adapters."

T. C. Lawson, "Transistor Front Ends for FM Tuners."

D. R. von Recklinghausen, "A Multiplex Stereo Generator."

These specifications govern stereo broadcasting in Canada

On September 1, FM stereophonic broadcasting officially started in Canada. The technical rules adopted in this country are essentially the same as those approved earlier this year by the Federal Communications Commission in the United States.

Here are the main features contained in the two relevant specifications issued by the Department of Transport, Radio Regulations Division, Ottawa. ▶

RULES FOR STEREOPHONIC FM BROADCASTING

(Broadcast Procedure 6, Issue 1, revised)

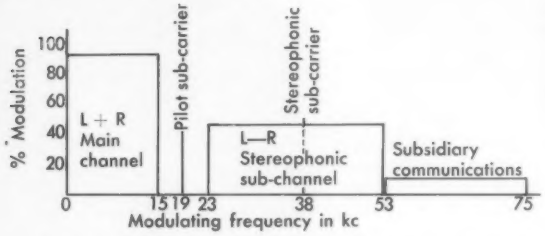
Definitions

2(a) Cross talk: an undesired signal occurring in one channel, caused by an electrical signal in another channel.

(2(b) FM stereophonic broadcast: the transmission of a stereophonic program by a single FM broadcast station utilizing the main channel and a stereophonic sub-channel.

2(c) Left (or right) signal: the electrical output of a microphone or combination of microphones placed so as to convey the intensity, time and location of sounds originating predominantly to the listener's left (or right) of the centre of the performing area.

2(d) Left (or right) stereophonic channel: the left (or right) signal as electrically reproduced in reception of FM stereophonic broadcasts.



2(e) Main channel: the band of frequencies from 50 to 15,000 cps which frequency modulate the main carrier.

2(f) Pilot sub-carrier: a sub-carrier serving as a control signal for use in the reception of FM stereophonic broadcasts.

2(g) Stereophonic separation: the ratio of the electrical signal caused in the right (or left) stereophonic channel to the electrical signal caused in the left (or right) stereophonic channel by the transmission of only a right (or left) signal.

2(h) Stereophonic sub-carrier: a sub-carrier having a frequency which is the second harmonic of the pilot sub-carrier frequency and which is employed in FM stereophonic broadcasting.

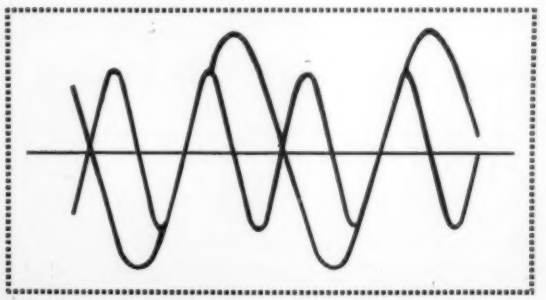
2(i) Stereophonic sub-channel: the band of frequencies from 23 kc to 53 kc containing the stereophonic sub-carrier and its associated sidebands.

Stereophonic transmission standards

3(a) The modulation signal for the main channel shall consist of the sum of the left and right signals.

3(b) A pilot sub-carrier at 19 kc $\pm$ 2 cps shall be transmitted, and shall frequency modulate the main carrier between the limits of 8% and 10%.

3(c) The stereophonic sub-carrier shall be the second harmonic of the pilot sub-carrier and shall cross the time axis with a positive slope simultaneously with each crossing of the time axis by the pilot sub-carrier.



3(d) Amplitude modulation of the stereophonic sub-carrier shall be used.

3(e) The stereophonic sub-carrier shall be suppressed to a level less than 1% modulation of the main carrier.

3(f) The stereophonic sub-carrier shall be capable of being modulated by audio frequencies from 50 to 15,000 cps.

3(g) The modulation signal for the stereophonic sub-carrier shall be equal to the left signal minus the right signal.

3(h) The pre-emphasis characteristics of the stereophonic sub-channel shall be identical with those of the main channel with respect to phase and amplitude at all frequencies.

3(i) The sum of the side bands resulting from amplitude modulation of the stereophonic sub-carrier shall not cause a peak deviation of the main carrier in excess of 45% of total modulation when only left (or right) signal exists; simultaneously in the main channel, the deviation when only a left (or right) signal exists shall not exceed 45% of total modulation.

3(j) Total modulation of the main carrier including pilot sub-carrier, together with any other sub-carriers which may subsequently be authorized, shall meet all the requirements and standards of good engineering practices for frequency modulated transmissions in the band 88-108 Mc.

3(k) At the instant when only a positive left signal is applied, the main channel modulation shall cause an upward deviation of the main carrier frequency; also at this instant the stereophonic signal resulting from the sum of the sideband signals shall be in phase with the sub-carrier, the phase of which was established by 3(c). This positive sub-carrier signal shall cause an upward deviation of the main carrier frequency.

3(l) The ratio of peak main channel deviation to peak stereophonic sub-channel deviation when only a steady state left (or right) signal exists shall be within $\pm$ 3.5% of unity for all levels of this signal and all frequencies from 50 to 15,000 cps.

3(m) The phase difference between the zero points of the main channel signal and the stereophonic sub-carrier sidebands envelope, when only a steady state left (or right) signal exists, shall not exceed $\pm$ 3 degrees for audio modulating frequencies from 50 to 15,000 cps.

If the stereophonic separation between left and right stereophonic channels is better than 29.7 dbt at AM frequencies between 50 and 15,000 cps, it will be assumed that 3(l) and 3(m) have been complied with.

3(n) Cross-talk into the main channel caused by a signal in the stereo channel shall be attenuated at least 40 db below 90% modulation.

3(o) Cross-talk into the stereophonic sub-channel caused by a signal in the main channel shall be attenuated at least 40 db below 90% modulation.

3(p) For transmission performance the reference modulation shall be 90% rather than 100%. This will exclude the pilot sub-carrier.

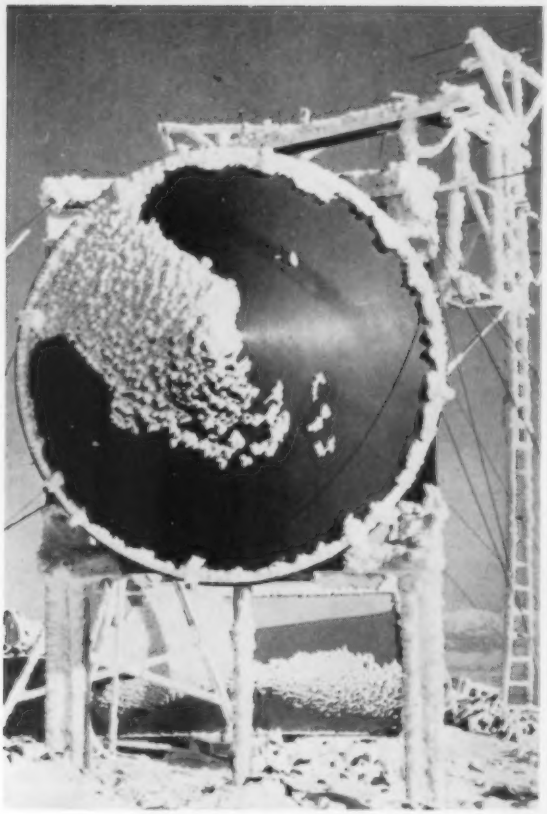
3(q) Electrical performance of the transmitter and associated equipment when carrying a complete complement of stereophonic program material, together with the pilot sub-carrier, shall be referred to 100% modulation.

RULES FOR SUBSIDIARY COMMUNICATION MULTIPLEX OPERATION

(Broadcast Procedure 7, Issue 1)

The following rules govern the use of multiplex transmission on frequency modulated broadcasting stations operating in the band 88-108 Mc for subsidiary communication purposes other than for stereophonic broadcasting.

(Continued on page 47)



Accumulation of foreign matter in horizontally mounted parabolic antennas produces serious signal loss in microwave relay systems. This article presents the results of tests with ice, snow and leaves. Analysis shows the cause of the loss.

Tests show how snow, ice and leaves in microwave antennas cause signal loss

FRANK R. WILLIS*

Until recently, little has been known of the effect of foreign matter on the performance of parabolic antennas in the 7 Gc region. In an engineering program conducted at Andrew Corp., this problem was studied mathematically and experimentally.

Ice, snow and leaves have properties similar to dielectric materials. When they are introduced into a parabolic reflector the electro-magnetic field is distorted by a change of velocity or phase delay, and by the absorption of power.

The dielectric constants and dissipation factors for ice, freshly fallen snow and packed snow can be found in handbooks, such as "Reference Data for Radio Engineers," published by The International Telephone and Telegraph Corporation. For a thickness of one free space wavelength of these materials, freshly fallen snow (dielectric constant of 1.2) would have a phase delay of 35 deg. compared to free space; for packed snow (dielectric constant of 1.5) the phase delay would be 80 deg., and for ice (dielectric constant of 3.2) the phase delay would be 280 deg.

Attenuations in the same thicknesses of material can be determined using the following formula from Volume 12 of the M.I.T. Radiation Laboratory Series (McGraw-Hill Co. of Canada Ltd., Toronto):

$$A = 27.3\, n^{e''/e'} \quad \text{or}$$
$$A = 27.3\sqrt{e_r}\ (D.F.)^{db}/\lambda$$

Attenuations would be 0.009 db for freshly fallen snow, 0.03 db for packed snow and 0.045 db for ice at 3 Gc.

From the characteristics of a parabolic reflecting surface shown in Figure 1, the effects of these dielectric materials can be demonstrated. With a clean surface the distance from the focal point along any ray to a reference plane perpendicular to the axis of the antenna is the same as along any other ray. The lines FAA′, FBB′ and FCC′

*Product Development Engineer, Andrew Corporation, Chicago, Illinois.

This paper was originally presented at the 1961 IRE Canadian Electronics Conference.

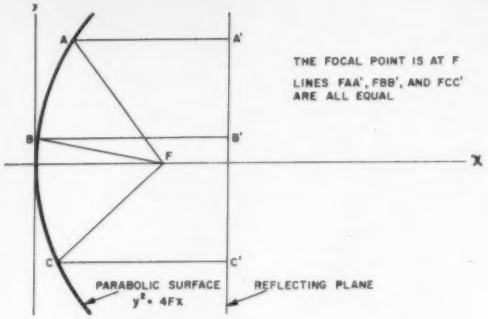


Fig. 1. Characteristics of a parabolic surface.

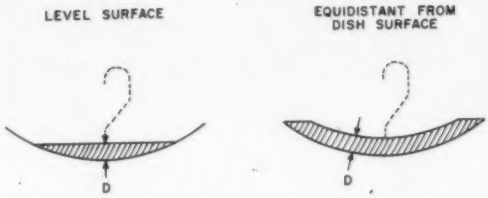


Fig. 2. Distribution used in systematic tests.

are all equal. Therefore, the energy radiated by a feed at the focal point will be in phase at the reference plane and the antenna will have maximum gain.

Now, if a dielectric material is distributed over the surface of the reflector this plane phase front will be distorted. In the experiments, preformed snow was distributed over the reflector surface in two ways as shown in Figure 2.

In the first case, the surface of the snow was kept level and in the second it was kept equidistant from the reflector surface.

In the case of a level surface, distribution of the material over the reflector surface is uneven and the phase front will be greatly distorted. For freshly fallen snow 2.6 wavelengths, or 4⅜ inches deep at the centre of the reflector, the field at the centre of the aperture would be 180 deg. out of phase with the field at the edges of the aperture and result in a low antenna gain. The effect would be cyclic with increasing depth of material and dielectric constant.

With the material distributed equally over the reflecting surface, the effect on the phase front would be less than in the previous case. This is because the phase delay would be nearly the same over the entire reflector surface.

These conclusions are in agreement with the results of the experimental program, as will be shown later.

Because the dielectric properties of natural ice, snow and especially leaves are so variable due to their heterogeneous nature, the examples just given, and the experimental results to be described, can be taken as only an indication of the effects these materials will have.

Operator sprays glass fibre and resin into a mold to form a conical radome. Finished unit has a coating of non-conductive paint and mounting clips attached to the rim. Heated radomes have a spirally wound heater wire embedded in them and are controlled by a thermostat to operate at between 25 and 35 deg. F.

How tests were conducted

The test setup used to measure the effects of snow consisted of two horizontally mounted 4-foot diameter antennas, with a small receiving horn antenna located 40 feet above them. One of the antennas was covered with an unheated radome to check the effects of using it.

Because tests could be performed only with fresh snow, the number of tests was limited to the number of adequate snowfalls. The transmitted and received signals were measured when the antennas were clean, either before or after the snow tests were made. With freshly fallen snow on the antennas, transmitted and received signals were measured; the difference between readings with and without snow represented the loss in signal strength due to the snow.

The first opportunity for a test was a combination of rain, sleet and snow. This resulted in a build-up of 4 inches of solid ice and 4 inches of icy snow completely filling the uncovered antenna. The radome on the other antenna was partially covered with a layer of ice and snow about 1½ inches thick at the edge and tapering to zero at the tip.

Under these severe conditions the uncovered antenna had a loss in signal of 22 db and the antenna with the radome had a loss of 6 db. Even though the antenna with the radome had a fairly high loss for these conditions, there was the advantage that the ice and snow would have melted after a few sunny days. The block of ice in the unprotected antenna could have remained for the rest of the winter. The radome used in these tests had a loss of less than 0.4 db.

The next test was of a cold powder snow blown by a strong wind so that very little of it stayed in the open reflector, and less stayed on the radome. There was a maximum of 1 inch of snow spread over most of the

Table 1

Loss due to snow in a horizontally mounted antenna

Type of snow	Loss in db for depths shown			
	2″	4″	6″	8″
1. Icy snow particles up to ⅛ inch in diameter. Level surface. Date: Feb. 16, 1960	3.9	9.8	17.5	28.2
2. Fine snow particles slightly sticky from being warmed by the sun. Level surface. Date: Feb. 23, 1960	0.7	10.4	12.8	9.8
3. Same snow as 2. Equidistant from dish surface.	1.9	4.7		
4. A heavy fine snow similar to 2. Level Surface. Date: March 1, 1960	1.6	17.8	8.2	11.6
5. Repeat of 4.	2.4	11.4	7.2	11.1
6. Same snow as 4. Equidistant from dish surface.	2.6	4.0		

Table 2

Loss due to leaves in a horizontally mounted antenna

Condition of leaves	Loss in db for depths shown							
	1″	2″	3″	4″	5″	6″	7″	8″
1. Dry Oak Leaves	—0.10	—0.25	—0.35	0.00	0.25	0.90	1.15	1.65
2. Damp Oak Leaves	1.40	2.80	4.35	7.45	10.40	11.05		
3. Mixture of leaves soaked in water (Oak, Elm, Silver Maple, and Cottonwood).	6.55	7.60	10.55	13.10	17.45	20.10		

reflector surface. There was also a thin layer of ice at the centre of the reflector. These conditions resulted in a loss of about 0.5 db for the unprotected antenna. The snow had melted off the radome before the tests could be completed.

These two tests were the only ones made using the snow as it had fallen on the antennas. To obtain additional information, using the snow that was available, the reflector of the unprotected antenna was systematically filled with snow from the ground. This was done in the two ways shown in Figure 2; the results are shown in Table 1.

The first test listed in Table 1 was from the early snow fall, which was more ice than snow, and produced a large loss in signal. Notice that the loss is greater for the level surface condition when the reflector is not completely filled, thus showing the effect of phase distortion. Notice also in numbers 3 and 6, for the same snow, that the loss is less when the snow is distributed evenly over the reflector to a depth of 4 inches than when the surface is level with a depth of 4 inches at the centre.

Testing the effect of leaves

Using the same test setup described above, the reflector was systematically filled with leaves in three different tests, using the level surface condition. The results are shown in Table 2.

The system was first tested using dry oak leaves; they have little effect on the signal. The leaves were then dampened and the test repeated. Now the loss was much greater because of the water present on the leaves.

Next, a mixture of oak, elm, silver maple and cottonwood leaves were soaked in water and the test repeated. Again, the loss increased due to the increased amount of water present. In the tests, the leaves were kept as loose as possible.

The experimental results and the analysis presented show that there is a serious loss in signal strength due to the accumulation of ice, snow or leaves in a horizontally mounted antenna, and that in the case of ice and snow, this loss is due primarily to cancellation effects from phase distortion rather than the absorption of power. Therefore, it is recommended that in areas experiencing these conditions, a protective radome be used. In most situations the use of an unheated radome is quite sufficient; only when there is a severe icing problem is the use of a heated radome required. END

Stereo broadcasting—continued

Transmission standards

3(a) Frequency modulation of subsidiary communications sub-carriers shall be used.

3(b) The instantaneous frequency of subsidiary sub-carriers shall at all times remain within the range of 53-75 kc.

3(c) The arithmetical sum of the modulation of the main carrier by subsidiary communication sub-carriers shall not exceed 10%.

3(d) More than one subsidiary communications sub-carrier may be used simultaneously provided that the conditions set forth in the Standards are met at all times and under all conditions of operation.

3(e) Frequency modulation of the main carrier caused by subsidiary communication sub-carrier operation shall in the frequency range 150-53,000 cps be at least 60 db below 100% modulation. This condition shall apply whether or not stereophonic transmissions are being carried simultaneously.

3(f) Cross-talk between any subsidiary communication multiplex channel and the main channel shall be at least 60 db below 100% modulation. END

Electronics industry pledges support of Ottawa research plan

Wholehearted co-operation by members of the Electronic Industries Association of Canada for the Government's program to encourage industrial research and development, was pledged by J. D. Houlding, president of the Association. His promise was made last month during a meeting between members of EIA's electronics division and John L. Orr, Director of Industrial Research, Defence Research Board.

Research is vital to defence

Stating that Canada has already made the transition from a primary into an industrial economy, Mr. Orr recalled Sir Winston Churchill's comment that "the battle line of tomorrow runs through the research laboratories of today." to explain why the Directorate of Industrial Research had been established. (See page 35, CEE, Nov. 61.)

Mr. Orr explained that production capacity is no longer a critical problem in supplying military weapons and equipment.

"The real limiting factor is the research and development capability of defence industry to meet the rapidly changing requirements of the Armed Forces. Firms supplying the military market must acquire a substantial research and development capability in order to remain competitive," said Mr. Orr. "Another direct consequence of these influences has been the inability of the smaller nations to undertake the independent development of major weapon systems. This is reflected in the decreased development budgets of the Canadian Services. Conversely, this situation has provided a strong impetus toward collaborative development projects in both the Tripartite and NATO contexts. Under these circumstances, Canadian defence industry could obtain access to much wider markets, providing that it first establishes a superior competence in selected areas of defence technology."

Mr. Orr pointed out that a highly skilled manufacturing capability has been built up in Canada, but with notable exceptions. The R & D capability required to make this industry self-sustaining has been lacking.

Canadian research budget is small

"Perhaps the most striking statistic of all is the inordinately low level of Canadian Government support for industrial research and development," said Mr. Orr. "The United Kingdom figure is eleven times greater, while the United States figure is 18.5 times higher.

"It has been the defence budget which has usually provided the major stimulus for technological advance in both the U. S. and U. K. with substantial benefits to the civil economy."

The program of Production Sharing with the U. S. Department of Defense was initiated in 1958, recalled Mr. Orr, and because the firms which had undertaken development of equipment were in the best production position, a program of Development Sharing was established to enhance the ability of Canadian defence industry to compete.

"However," said Mr. Orr, "in order to become self-sustaining, any continuing development activity requires a steady flow of new ideas and information from the research laboratories. In other words, research and development must go together; for development cannot long survive without the essential stimulus and back-up from research.

"In Canada, we have some excellent basic and applied research laboratories, mostly in government establishments and to a lesser extent in universities. In spite of this, we have not been particularly successful in exploiting the results of our basic research. This is a task for industry but, due to many factors quite apart from the lack of financial support, we have not bridged the gap.

"It was in recognition of all these factors that the government established the Defence Industrial Research Program."

Industry will be expected to advance new ideas for research projects, to which the government is prepared to make a substantial financial contribution.

"This will be particularly important," said Mr. Orr, "for we believe success will be dependent upon the interest and motivation of industrial firms, as well as in their research activities."

He said that preference will be given to longer term projects offering good potential for achieving major advances in performance or technique, rather than projects offering only marginal improvements over the current state-of-the-art. It is expected that the research will be undertaken in Canada and that the contractor can demonstrate a capability for the subsequent development and manufacture in Canada of the product of research. Initially, it is proposed to establish applied research programs in the following fields: Electronics and physics; Prime movers, energy conversion and propulsion systems; Defence materials; Aeronautics; Transportation systems and mechanical engineering; Weapon technology.

Canadians must specialize

Mr. Orr explained that, "our program must be selective since we cannot afford to dissipate our limited resources over too broad a front. Therefore, Canadian defence industry must specialize in certain areas in order to achieve the required degree of technological superiority by concentration of effort.

Industrial contractors will retain all proprietary rights except for royalty-free use of any inventions by the Canadian government and the right to disseminate technical information for defence purposes.

"The government," said Mr. Orr, "has already provided tax exemptions for expenditures (both operating and capital) which should assist the contractor in sharing the cost of projects under the development and research scheme."

1959 RESEARCH & DEVELOPMENT EXPENDITURES

	Canada	U. S.	U. K.
Total national expenditure	$253m	$12,430m	$1,338m
% G.N.P.	0.72%	2.58%	2.11%
Total industrial R&D	$99m	$9,400m	$745m
% of national total	39%	76%	56%
Gov. financed ind. R&D.	$21m	$5,400m	$432m
% of total industrial	21%	57%	58%
% G.N.P.	0.06%	1.12%	0.68%
Ratio	1	18.5	11.3

Reference: Copy of J. L. Orr speech

When Dr. C. J. Mackenzie, former president of the National Research Council, cut this metalized ribbon it cleared the path from a transmitter to a receiver via a satellite model. The signal marked the opening of Northern's Laboratory.

Northern Electric research and development laboratories

New facility will help shape future of communications in Canada

IAN R. DUTTON, ASSOCIATE EDITOR

Two significant facts stood out when Dr. C. J. Mackenzie formally opened the Northern Electric research and development laboratories on November 13.

The first is that his ribbon-cutting act completed a project started six years earlier.

The second is that the new laboratories represent approximately half of all the industry-owned electronics research facilities in Canada.

It was in 1955 that Dr. Mackenzie, former president of the National Research Council, undertook a survey of research and development activities and potentials of Northern Electric Co. It had become evident to the Northern management that R&D within the company should be increased, especially in the field of telephone communications.

As a result of the report, A. B. Hunt was appointed general manager, research and development, charged with organizing a separate group to integrate all the company's activities in R&D. The new facility has followed Dr. Mackenzie's original plan very closely, except that the buildings, staff and expenditures are almost ten times larger than he had visualized for the first few years of operation.

Two buildings have been completed on the 70-acre site two miles west of Ottawa. This provides over 100,000 sq. ft. for a staff of 400 (it is 250 at present), with provision for two more buildings which could provide accommodation for a total staff of 1,000.

Extensive facilities have been installed for the technical staff of the laboratories: Small tools and test sets amount to about $14,000 per member of the scientific staff. Adding on machinery, furniture, and all the other necessary specialized equipment, the total investment comes to about $5 million — a figure which matches the cost of the buildings.

At the present time, almost all the research projects are on commercial work, with only a small number of government contracts. Telephone transmission and switching, electronic equipment for the broadcast and industrial field, and solid state devices of all kinds are on the program of the laboratories.

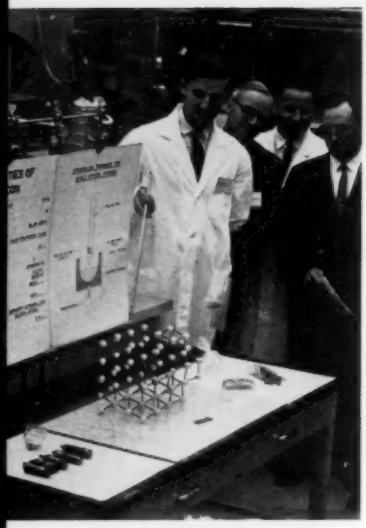
In the telephone field, they are working on several carrier systems for more economical operation under Canadian conditions. In the switching field they are trying to improve existing electro-magnetic systems and to apply electronic techniques to switching telephone and telegraph signals.

The electronics group has recently produced a line of transistorized video equipment, including video and pulse distribution amplifiers, and a synchronizing signal generator.

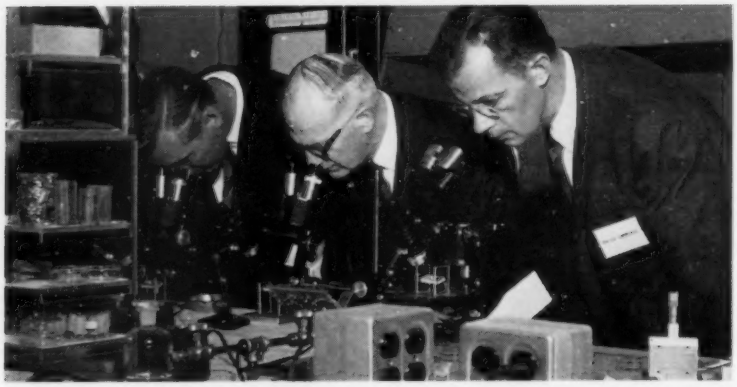
Some of the most basic research takes place on semiconductor materials and devices. Intensive studies are in progress of diffusion processes and masking techniques for epitaxial and planar structures. Other work emphasizes the control of impurities in germanium, silicon and gallium arsenide so that the desired properties can be obtained at will for different device designs. A recent addition has been the fabrication of integrated circuits, or molecular electronics. ▸

Tour of the new Northern Electric Research & Development Laboratories

This demonstration shows some of the recent developments in closed circuit television, and in video switching.



T. Rawlins uses model to explain structure of silicon crystals.



In one of the transistor laboratories, visitors inspect a demonstration of planar transistor construction.

D. G. Vice demonstrates components of a parametric amplifier developed for use in radar installations.

In the audio and video systems laboratory, engineers and scientists work on problems and circuits for the broadcast, television and industrial branches of electronics.

The communications network laboratory is equipped with an IBM 1620 computer to facilitate design of new networks.

A scientist takes Hall coefficient measurements while investigating impurities in semiconductor material.

Exploratory studies involving transmission of digital data signals over communication message channels.

Fundamental development offers opportunities for investigation into the use of new solid state devices in the microwave region.

A quiet, well-stocked library is a great asset in any office, but in a research establishment it becomes a vital necessity.

Designing complex filter networks frequently calls for accurate graphical methods.

END

Solid state devices change economics of microwave systems

JOHN E. RAFTIS*

The use of transistors and other solid state devices has changed the financial position of manufacturers, installers and operators of microwave systems. The relative cost of fixed plant and services, both of which are usually sub-contracted, has gone down. A description of new Motorola equipment is given after a discussion of economics.

Some interesting cost figures can be deduced from the analysis of commercial microwave systems. In one such study of twenty systems, it was found that construction of a typical microwave system involves expenditure in the neighborhood of $2,000 per linear mile, or about $150 per channel mile. Operation and maintenance of the system requires an annual expenditure of about 10% of the completed cost. Such a system will prove-in, when compared with other communications media, at somewhere between 5 and 50 derived channels, depending on local situations.

A microwave system involves three distinct types of investment before it becomes operational. These investments are in the active equipment—electronic elements used for the transmission of intelligence; in the passive equipment—fixed plant required to sustain the active elements; and in the services associated with design and construction. Investment in a typical system, ready for commercial service, might be distributed as follows:

TYPE OF INVESTMENT	PERCENTAGE OF TOTAL
Electronic Elements	50%
Fixed plant	40%
Services	10%

Position of system manufacturers

Companies engaged in supplying microwave facilities to common carriers and right-of-way users on a competitive basis in Canada, have had to maintain a broad scope of activities. The consulting services required to support the sale of microwave equipment include: aiding the customer in defining his requirements; preparing drawings and establishing specifications for RF and multiplex equipment, and for ancillary items such as buildings, towers, antennas, transmission lines, engine generators, etc.; selecting microwave frequencies; surveying to determine locations for relay stations, possible propagation difficulties, tower requirements, etc.; selection and installation of RF equipment. In some instances, the microwave supplier has sub-contracted the construction of access roads, towers, and buildings to house the equipment.

It is generally recognized that microwave system manufacturers do not realize a profit on sub-contracted work or on purchased equipment. A supplier able to provide all the electronic elements from its own plants is thus attempting to maintain the comprehensive consulting services outlined, from the profit on 50% of sales volume. In addition, and perhaps of greater importance to the industry over the long term, the user is obtaining service and return from 50% of investment, since only this portion is used for communication.

In effect, microwave facilities installed to date, for all their glamor, have represented a significant "no return" investment for the owner and a low profit margin for the system manufacturer.

Progress in the art

Despite the fact that the industry invested millions of dollars in basic research, engineering development and product design, there were no significant technological breakthroughs in the microwave art from 1950, when the first systems were installed, until 1960, when solid state products were announced.

The introduction of solid state microwave products is important in two ways, which can be seen when the typical system investment is revised to reflect their use:

TYPE OF INVESTMENT	PERCENTAGE OF TOTAL
Electronic elements	70%
Fixed plant	25%
Services	5%

With these products, the user has a higher percentage of his money invested in working equipment, and the manufacturer is capable of building a correspondingly greater portion of the microwave facilities.

There is a further advantage. It has been accepted practice for the owner to write-off investment in electronic equipment over a 10-year period and fixed plant over a 20-year period. With solid state products, writing-off the electronic equipment over 20 years can be justified.

Development of product lines

The costs incurred by microwave suppliers in performing the function of systems manufacturers dictated a larger return on microwave sales. This resulted in the original suppliers of RF equipment adding to their proprietary product lines.

For example, Motorola first entered the market with RF equipment and order wire. A simple fault alarm was then added, followed by proprietary antennas, and FM multiplex and sub-multiplex. More recently, its product line has been expanded to include a protective relaying carrier, a comprehensive supervision and control system, a modern alarm system, a high capacity SSB multiplex system, and a flexible sub-multiplex. The last three products were introduced at the same time as the first solid state microwave equipment, type MR-50, and are complementary to it.

*Manager, Microwave and Industrial Products, Canadian Motorola Electronics Co., Toronto.

The microwave industry can benefit from any of the following changes: lower production costs, better marketing of equipment, customer education, exploitation of higher frequencies, increased reliability.

Motorola's basic approach to the design of solid state microwave equipment has stressed margin of operation to improve dependability in service, with product configurations that result in lower production and maintenance costs. The overall development and design program has covered a period of some three years.

FEATURES OF MR-50 EQUIPMENT

Some 25 distinct features have been incorporated in the MR-50 solid state RF package, compared to previous vacuum tube equipment. These include reduction in size of a typical repeater by a factor of four; introduction of logic performance sensing with fail-safe design; modular construction with front access to all components; bilateral high-speed switchover; 48-volt battery operation with built-in voltage regulation; distortion-free performance with and without AFC; RF generation stable to 0.005%; stable IF gain and performance; and 1-watt transmitted power.

Component reliability

Transistorization greatly reduces the stresses of heat and voltage. When conservatively applied in stabilized, temperature-compensated circuits, the transistors, and the circuits themselves, have an almost indefinite life. The transmitter klystron is of the highly reliable probe-coupled type, earlier versions of which have had average lives of 20,000 hours.

All relays were replaced by static switching devices, thereby avoiding the problems of contact contamination, bounce, and pressure adjustments. In hot standby, bilateral switchover applications, individual transmitters and receivers are separately coupled to their common manifold waveguide system by zero-mass ferrite switches. Thus all automatically moving parts are eliminated, including relays, coaxial switches, waveguide switches, thermostats, fans and blowers. The advantages of static switching are particularly significant where switching operations are infrequent, and where the atmosphere is dust-laden, corrosive or explosive.

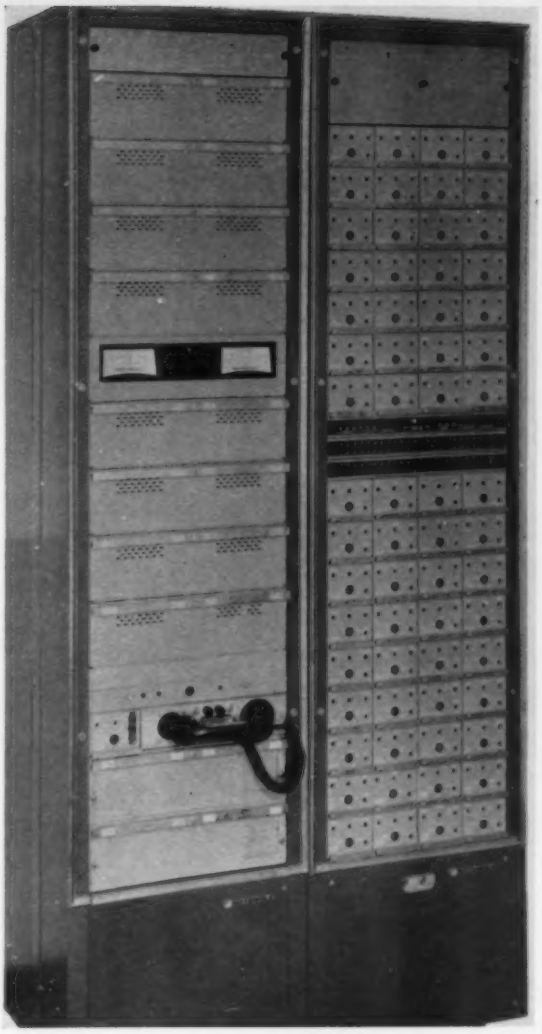
It is difficult to predict the exact improvement in component reliability (mean-time-to-failure) achieved by transistorization and static switching. However, it is estimated that the frequency of component failures will be reduced to one-sixth of that of previous equipment.

Circuit reliability

The most significant circuit improvements are in transmitter frequency stability and in the design of the local oscillator.

Long term stability is accomplished by distortion-free AFC action referenced to a crystal-controlled oscillator source for each transmitter in the system. With a short-term crystal oscillator stability of 0.0005%, a long-term stability of 0.003% from —20 to +130 deg. F. is assured. With an AFC error of 0.0015%, an overall transmitter stability of 0.005% can be maintained with only annual frequency checks.

The AFC circuit requires no moving parts. The klystron has a specially designed AFC control grid, thereby avoiding repeller plate control. Frequency correction by the repeller voltage method can cause operation over the non-linear portion of the modulation curve, which introduces additional distortion into the system and reduces channel performance. The special control grid does not degrade the per-hop distortion characteristic, and assures operation at the peak of the power mode.



Left rack: MR-50 RF equipment. Right rack: multiplex, sub-multiplex and MA-50 alarm system modules.

The local oscillator klystron has been replaced by a solid state crystal-controlled oscillator source with a long-term stability of 0.003%. The stability of both transmitter and receiver local oscillators eliminates the need for receiver AFC. Nevertheless, the displacement error between transmitters and receivers is less than in previous systems using receiver AFC.

In systems with receiver AFC, correction voltages are derived from the receiver IF strip discriminator. During deep fades, or when the distant transmitters are switched over, the noise balance of the receiver and IF strip is critical. Without perfect balance, the local oscillator will track the noise off-frequency, often beyond the capture range of the AFC circuitry, resulting in "AFC lockout" or capture by local transmitter signal or spurious radiation. Even more important is the fact that during the interval before the receiver AFC has caused the receiver to track the distant transmitter, the distortion of the system becomes excessive, causing tone control channels, alarms and signalling to operate falsely.

Maintenance reduced

Particular attention has been given to convenience and speed of servicing. All servicing is from the front of the rack, a central panel being provided for routine meter readings. Functional circuitry, such as modulation and IF amplifiers, are plug-in modules that may be easily exchanged in the field. The few controls and adjustments provided are covered, and do not appear on the outside surfaces of the racks.

The equipment requires less maintenance because of the conservatively rated, highly stable circuits, and the extensive use of long-life solid state devices. The need for routine transmitter frequency checks is virtually eliminated. Because there is no receiver AFC, there is no need for critical adjustments such as IF strip noise balance, AFC limit and balance, and local oscillator klystron mode balance.

Performance margins

The MR-50 provides better performance in derived channels. The additional power output of the transmitter klystron increases fade margins and results in additional propagation reliability. With the increased bandwidth of the IF strip and modulation amplifier, second and third order harmonic distortion is reduced to one third that of previous equipments. This results in a 10-db improvement in intermodulation noise in 3-kc derived channels.

The intrinsic noise of a given multiplex channel is also minimized by RF equipment with a high peak deviation, high transmitter power, and a low receiver noise figure. The highest peak deviation of ± 3 Mc is used, providing increased signal-to-intrinsic noise performance in the derived channels. The nominal klystron output is 1.4 watts and the nominal receiver noise figure is only 14 db with a 20-Mc receiver bandwidth. The per-hop baseband frequency response is now ± 0.15 db from 1 kc to 1 Mc.

Long-term performance under a variety of environmental conditions is assured by the use of baseband gain regulation, a high degree of negative feedback in the modulation amplifiers, wider IF bandwidth, 25 db of reserve limiting in the IF strips, stabilized probe-coupled klystrons, and stable, rugged transistors in temperature-compensated circuits.

Equipment packaging

The RF equipment is self-contained in one rack without the requirement for external power supplies or other units. An entire repeater station with standby equipment, termination panel, meter panel, alarm transmitter, pilot generator, and baseband channel unit are all contained in one rack.

The major units and their controls are protected by swing-down panels; no knobs are left protruding for accidental misadjustment. Behind these panels, the circuits are mounted in plug-in modules, with front access to all controls and test points. The selector switch on the meter panel chooses any transmitter, receiver or power supply for observation. The rack location number appears in an aperture above the selector, and an indicator lamp lights on the swing-down door of the chosen unit.

The packaging of individual transmitters and receivers permits a flexible arrangement of equipment. A total of eight transmitters and receivers in any combination may be manifolded to an antenna. A standby repeater station has two vertical waveguides which connect to the two transmitters and two receivers of each direction.

Standby arrangements

The standby design is flexible, providing hot switchover, bilateral switchover, independent switchover, and high-frequency sensing.

For hot switchover, all units are operating and sensed continuously, the standby transmitter output being attenuated so that its signal does not enter the manifold.

With bilateral switchover, when both units are in working order, either one may be the "reserve" or the "in-service" unit. If a fault occurs in an "in-service" unit, that unit switches to the "reserve" condition. Maintenance calls are not required to reset these units.

Independent switchover means that a transmitter and its associated receiver do not both switch over in the event of a fault in only one of the units. At a repeater station, for example, as many as two transmitters and two receivers may fail, but the station will still operate in both directions. This independent switching greatly increases reliability.

The high-frequency sensing system uses a sensing pilot, above 2 Mc, and an adjacent noise-comparison band. Both are filtered at each repeater station, then the pilot is reinserted. Both "in-service" and "reserve" transmitters, including their AFC circuits, are continuously and completely sensed. The receivers are continuously sensed and switched by pilot sensing and/or noise comparison techniques for the ultimate in reliability.

Receiver squelch

Loss of the incoming signal to a receiver results in high level noise which is re-transmitted down the system unless receiver squelch is used. In MR-50 standby equipment, a sensing receiver measures high frequency noise in both the "in-service" and the "reserve" channels. The squelch level at each receiver may be adjusted to a carrier-to-noise ratio that is proportional to the minimum desired multiplex channel signal-to-noise ratio.

Power requirements

Working on a 48-volt station battery, an MR-50 standby or frequency diversity repeater has a nominal power drain of 965 watts, with an additional 12 watts for the baseband channel unit. With a 115/230 volt, 60 cps supply, these figures increase to 1530 watts and 15 watts.

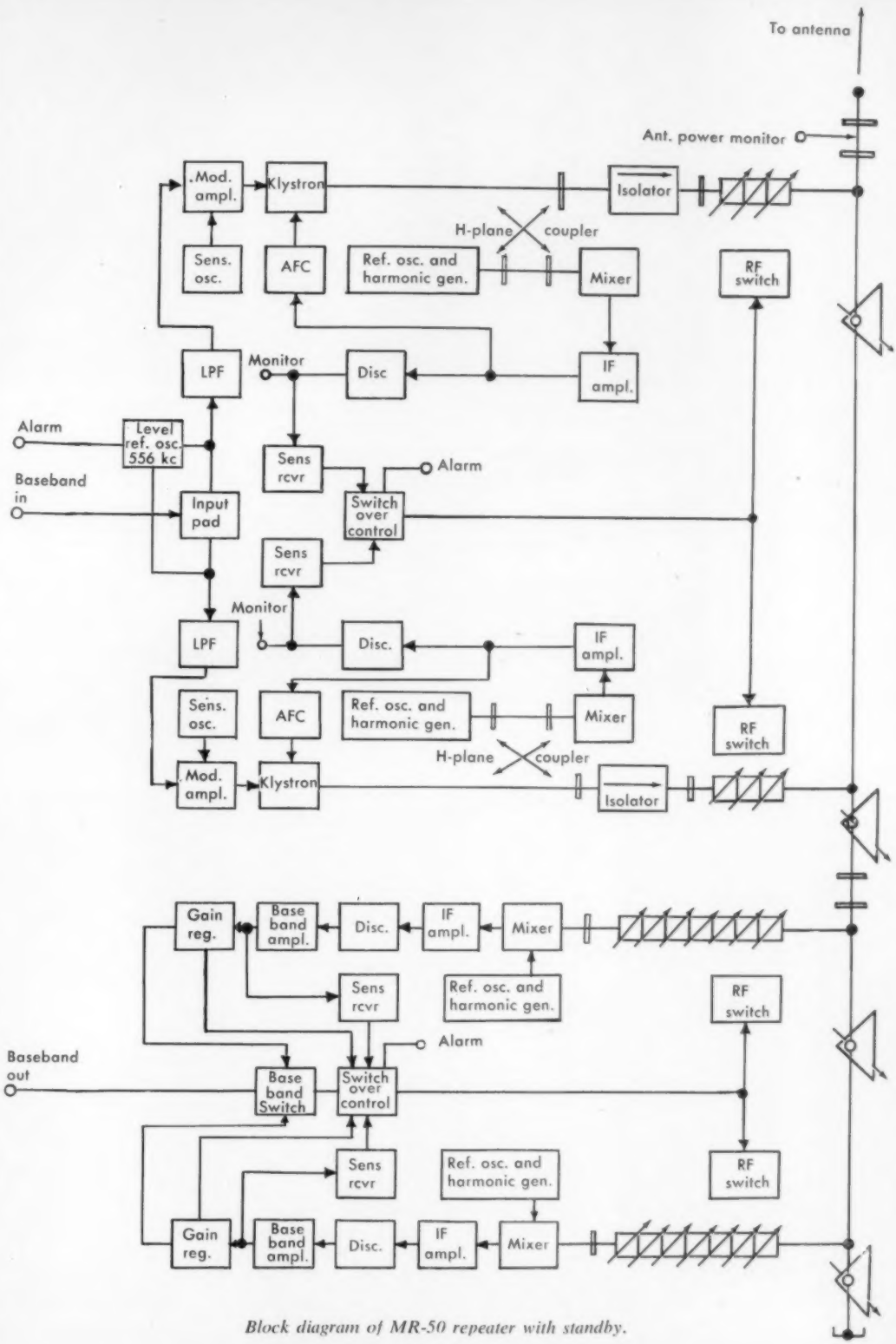
MA-50 alarm system

The MA-50 alarm system has been designed as companion equipment for the MR-50 and embodies the same advantages of transistorization: extended life, reduced maintenance, and reduced power requirements. The nominal drain on 48-volt battery supply for the alarm transmitter is 5 watts. An alarm indicator with 12 receivers uses 31 watts. With AC mains supply, these units are fed from power supplies in the RF equipment and represent additional drains of 5 watts and 23 watts respectively.

The alarm transmitter is essentially a transistorized scanner which uses a binary counter principle to scan each of eight alarm inputs at the remote station. A parallel-to-serial converter produces a train of polarity-coded "mark-space" frequency-shift pulses that are applied to the microwave baseband. At the indicator station, a frequency shift of the tone carrier is detected and the information is decoded for display on lamp indicators.

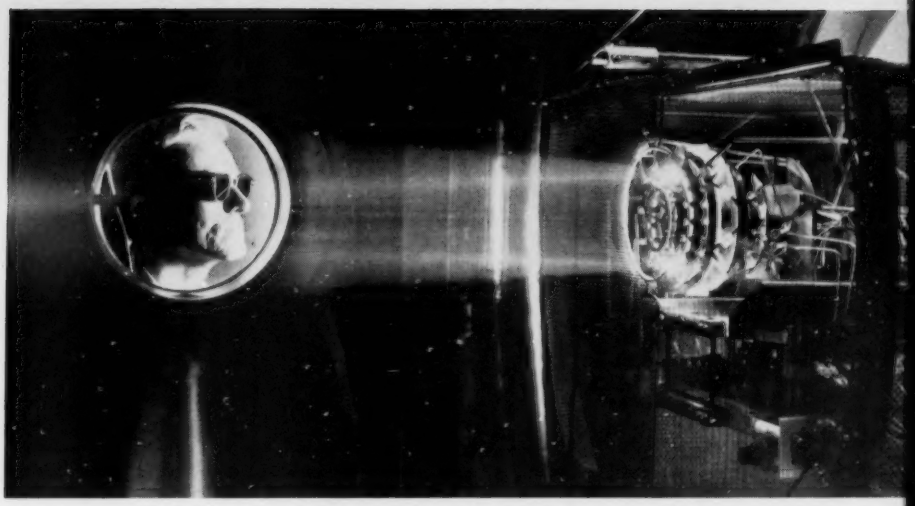
As many as 24 remote stations can be monitored for alarm faults with up to eight points per station. Each indicator station can monitor faults at 12 remote sites. Alarm information is transmitted only when a fault exists, keeping baseband loading to a minimum. This is important in high density systems.

Once a fault has been reported by a remote station, the lamp representing that station remains lit until the alarm is cleared. The operator can see at a glance which stations are being alarmed and can read out any alarm by a simple switching operation. Even if two or more stations develop alarms simultaneously, all reporting stations are identified. END

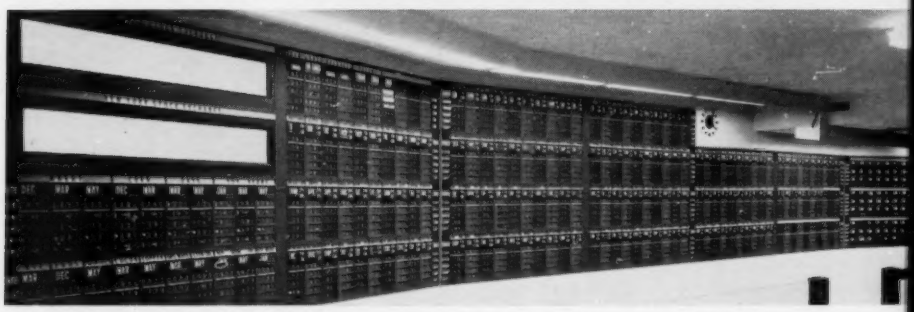


Block diagram of MR-50 repeater with standby.

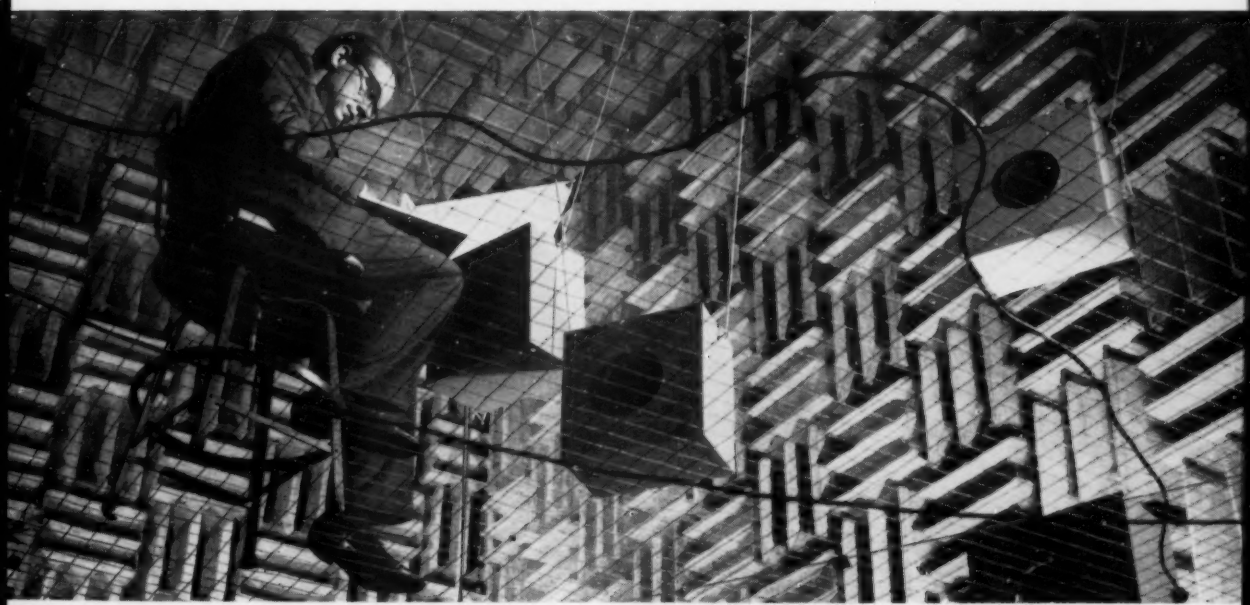
What's new in view



Ionized atoms shooting out of this working ion engine are viewed by a technician through a porthole in a space simulation chamber at Hughes Aircraft Co., Malibu, Calif.



This Teleregister automatic electric quote board in the Toronto office of Merrill Lynch, Pierce, Fenner and Smith, provides customers with up-to-the-minute information on stocks and bonds trading on the Toronto, New York and American Stock Exchanges.

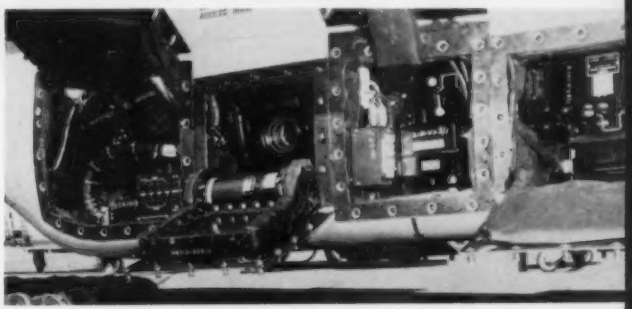


Dr. M. R. Schroeder of Bell Laboratories can evaluate the acoustics of a proposed auditorium before it is built. Music is processed through a digital computer programmed to act upon it just as the floors, walls, ceiling, etc., of the new hall would. Dr. Schroeder then listens to the music in an anechoic chamber to evaluate the results.

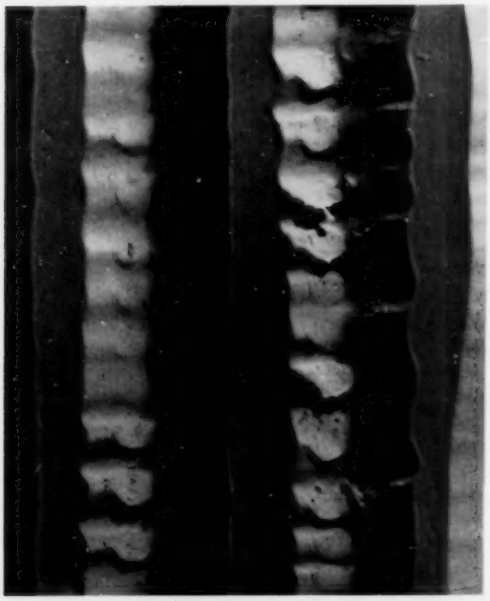
Helicopter lifts 2-ton Canadian General Electric TV antenna to 76-ft. tower on Mt. Tremblant, Que.

Meteorological radar developed by Cossor Radar & Electronics, England, can be expanded to suit station needs.

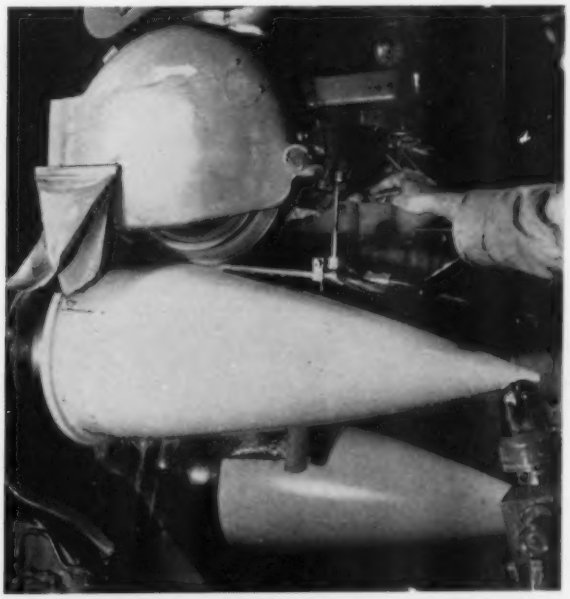
USAF K-135 jet tanker visited Toronto recently to have technicians from Philips Electronics Industries service its ion trail detection system.



Computing Devices of Canada designed the electronics for this VICOM low level, high speed reconnaissance camera system for the RCAF's CF-104 Starfighter squadrons.



C. Campos of Acoustic Research, Inc. and J. Facq of Fabric Research Labs have developed a new method of studying groove topography records.



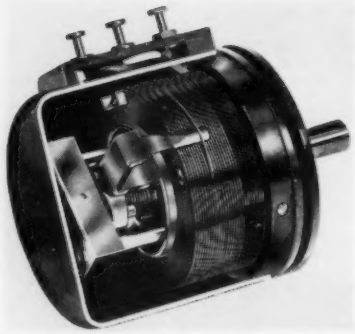
Corning Glass Works, Corning, N.Y., has developed a process for grinding Pyroceram (glass-ceramic material) radomes on a production basis to exacting prescriptions.

New components

Infinite resolution potentiometers 101

In the Vico infinite resolution wire-wound potentiometer a precious metal brush of extremely light pressure slides across a single helically-wound length of resistance wire. The brush follows the exact helical path of the resistance wire, thus no sliding or helical error occurs, ensuring long wire life, a true stepless output, high accuracy, and low electrical noise. Total resistance is as high as 30,000 ohms ±5%; linearity is 0.01%; maximum power rating is 8 watts; total turns is 40 on some models.

Electronic Marketing Co., Montreal.



Miniature 455 kc IF filters 102

This new series of LC network-type filters for FM communication receivers reduces ignition noise effects by minimizing the phase distortion and ripple in the pass band. These filters incorporate subminiature ferrite-cored high-Q coils and high quality silvered ceramic temperature-compensating capacitors. This results in stable tuned circuits giving negligible frequency drift over an extended temperature range. Centre frequency is 455 kc, adjustable ±500 cps; size is 1¼ x 2¾ x 1 inch.

Ferritronics Ltd., Willowdale, Ont.

Pure cobalt strip 103

Commercially-available for the first time, pure cobalt coiled strip with good ductility and workability is now offered in thicknesses ranging from .005 in. to .025 in. and widths of ¼ in. to 6 in. Pure cobalt metal in strip form has not been commercially available because it was said to lack the ductility and workability essential in metalworking operations. This new and more ductile cobalt strip, which is 99.9% pure, extends cobalt's working applications to a much wider range of products.

Cobalt has excellent magnetic properties which are retained to a higher Curie point than nickel. One promising application for cobalt strip is magnetic tape for computers.

Sherritt Gordon Mines Ltd., Toronto.

VHF and UHF base station high gain antennas 104

Model 229 VHF antenna has a frequency range of 148-174 Mc and is vertically polarized with an omnidirectional pattern. Gain over a half wave dipole is 5.8 db. Nominal impedance is 52 ohms. Power rating is 250 watts. VSWR is 1.5 or less at the design frequency, and bandwidth is 4 Mc for VSWR less than 2 to 1.

Model 318 UHF antenna has a frequency range of 400-470 Mc. It is vertically polarized with an omnidirectional pattern. Gain over a half wave dipole is 7.5 db. Nominal impedance is 52 ohms. Power rating is 100 watts. VSWR is 1.5 or less at design frequency. Bandwidth is 10 Mc.

Sinclair Radio Laboratories Ltd., Toronto.

Epoxy precoated sand 105

Hysol 4862 is an epoxy precoated sand, designed primarily for low cost potting. It handles in the same manner as dry sand, and requires no preparation prior to use. This material has an exceptionally high thermal conductivity following heat cure. It assists in the dissipation of heat around windings. An epoxy capping material is available for sealing the potted unit. Two types are available: type I is a blue epoxy sand with a very high specific gravity (and thermal conductivity); type II is green colored and more porous than type I. It is designed as a matrix for subsequent impregnation with transformer oil or with Hysol 4251 impregnant.

Hysol (Canada) Ltd., Toronto.

Time delay switch 106

These gas damped time delay switches, formerly available only on a custom basis, but now a standard product, are used primarily in applications where a time delay or acceleration-time integration is required. They can be set to function at ranges as high as 50 G—seconds.

Inertia Switch Inc., New York.

(Continued on page 61)

New instruments

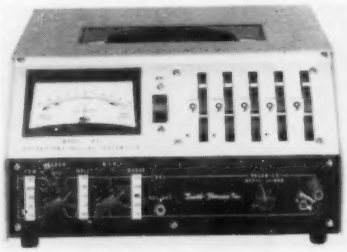
Measures phase angle directly in degrees 107

Model 526D Phase Unit is designed as a plug-in for Hewlett-Packard models 524B/C/D electronic counters. It equips the counter to measure any lead or lag phase angle between two signals in the 1 cps to 20 kc range. For frequencies from 396 to 404 cps, a X 3600 frequency multiplier provides readings direct in tenths of a degree. At other frequencies readings are presented in time units, with a resolution of 1 usec for full frequency range. Measurement accuracy of the 526D is $\pm 0.1° \pm (F_P/F_C) \times 360°$, where F_P is the frequency of the phase-measured signal and F_C is the counted frequency (assuming noise is 65 db below signal, and counted frequency error is negligible).

Hewlett-Packard Co., Montreal.

Differential voltmeter 108

A new solid state differential voltmeter with a 1 mv to 1 kv range and absolute accuracy of better than

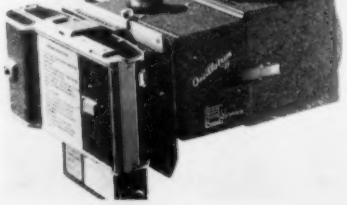


±0.05% has been developed by Smith-Florence, Inc. Known as the model 851, this new voltmeter also features a five-dial inline readout, zener reference backed up by a built-in standard cell, 0 to 10 volts dc precision source in 10 uv steps, and a recorder output. Input impedance is 10 megohms above 10 volts.

B. H. McGregor, Toronto.

Oscilloscope camera 109

Beattie-Coleman Mark II Oscillotron permits the operator to select any object-to-image ratio from 1:1 through 1:0.5 without extra lenses. Designed to fit any 5 in. oscilloscope, it provides external



New equipment

rack and pinion focusing, direct-viewing port, electric shutter, "shutter open" indicator light, rotating back for vertical or horizontal pictures, and Polaroid dark slide. As many as 13 multiple exposures can be made on one film. It is equipped with either Polaroid roll film back, or 4x5 cut film back, with ground glass focusing.

Alex L. Clark Ltd., Islington, Ont.

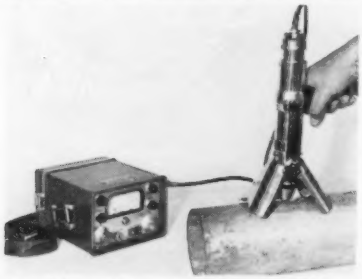
Microwave phase-amplitude measuring system 110

Phase and amplitude of the electromagnetic field over the aperture of an antenna can be determined with the new Scientific-Atlanta Model APA-1 antenna phase amplitude system. Operating frequency is 2 to 40 Gc with high sensitivity (180 dbm at 13 Gc). Phase accuracy and stability are better than ±5 deg. over 40 db dynamic range. Amplitude is measured to ±0.5 db.

Philips Electronics Industries Ltd., Toronto.

Metal wall-thickness gauge 111

EKCO metal wall thickness gauge N563 measures the thickness of pipe walls or sheet material when access is possible to one side only. It utilizes gamma rays backscattered from a built-in source. Wall thickness up to ¾ inch



of mild steel can be measured with an accuracy of 5% (diminishing to 10% on thickest section).

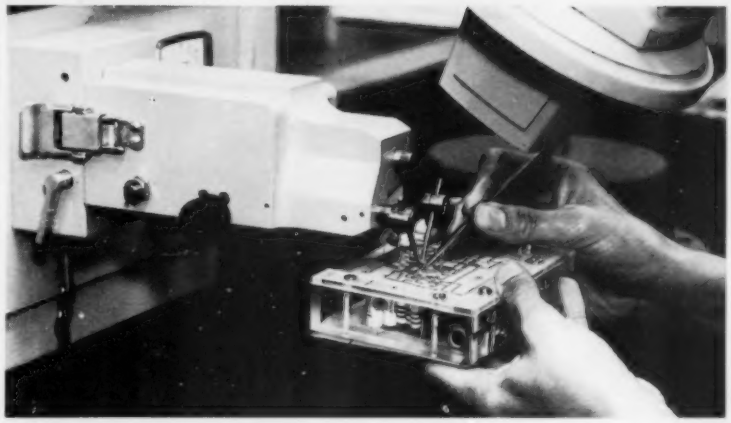
Electronic Controls Ltd., Belleville, Ont.

Reversing counters 112

Beckman model 3300 reversing counters are designed to count "up" or "down" at rates up to 200,000 counts-per-second. The basic instrument is provided with a single input channel and "sense" input for controlling the direction of counting. Plus lamp or minus lamp indicates the algebraic sign of the totalized counts at any given time. Instruments can be supplied with three to six digit read-out capacity. Optional features are available, such as dual input channels with A+B and A—B anticoincidence functions, accumulate-count gate control and automatic reset gate.

R-O-R Associates Ltd., Don Mills, Ont.

(Continued no page 68)



Precision welder 113

Sippicon Corp. has introduced a welder for production and laboratory fabrication of electronic sub-assemblies and systems packages. The welder features interchangeability of plug-in heads (both vertical and pincer) with any Sippicon power supply. The supply is regulated, offering variation in output voltage of less than 0.05 watt-sec or 2%, whichever is smaller, for all operating conditions. Input is less than 105-125 volts, 50/60 cps, 1.0 amp; energy storage is 0.4 to 40 watt-sec, and pulse width is 1.00 to 1.25 millisec. Both weld heads permit preset pressure and energy adjustments. The pincer head has a pressure range from 0.5 to 5 lbs; vertical head from 0.5 to 8 lbs. Throat depths are 9 and 7 inches, respectively. Both heads have the advantages of low inertia, exact electrode alignment and precise, spring-controlled pressure.

Willer Engineering & Sales Co., Toronto.

Television test signals 114

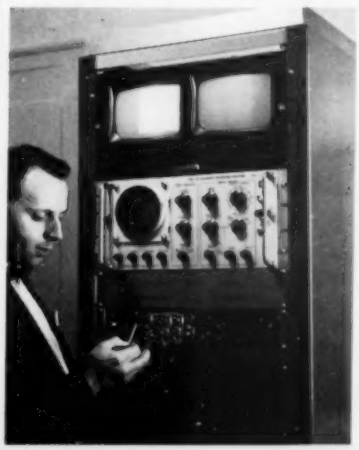
Utilizing solid state throughout, series 1500 TV test signals generators are in modular form allowing any combination of the following test signals to be supplied: (1) linearity generator (10 steps); (2) window generator; (3) multi-burst generator; (4) tape reference signal generator; (5) step wedge generator (5 and 6 steps); (6) four-input switch for local or remote selection of an individual test signal. The maximum combination in any one complete unit is dependent upon the space available. A complete unit will require two power supplies and one pulse regeneration card, leaving six card spaces available for test signals.

Richmond Hill Lab, Toronto.

Tap-master 115

A new tap-setting device has been introduced for inserting "push-in" type taps in DeJur wirewound precision potentiometers models C-200 and BC-200. Because of the tap design and method of fine wire winding of the potentiometer, the company claims it is not necessary to protect the winding while the taps are being installed.

Atlas Radio Corp. Ltd., Toronto.



(Continued on page 72)

CANADIAN ELECTRONICS ENGINEERING

Index of editorial features — 1961

Classifications used in this index correspond to the Professional Groups of the Institute of Radio Engineers. Articles are arranged alphabetically under each classification.

Aerospace and Navigational Electronics — Issue Page

Montreal Airport's electronic facilities provide business for many firms, Harold Price ..... Jan. 41

Slowed-down video permits transmission of radar pictures over telephone lines, T. W. R. East and M. M. Feilchenfeld ..... Nov. 36

Symbol generator helps air traffic controllers identify and direct aircraft, R. W. Dankwardt Nov. 39

Antennas and Propagation

Tests show how snow, ice and leaves in microwave antennas cause signal loss, Frank R. Willis ... Dec. 41

Audio

Air terminal building sound system incorporates latest techniques, Eric Handley ..... Jan. 44

Co-ordinated aural and visual aids set high standard for auditoriums, N. A. C. Lewry ..... Oct. 48

Broadcasting

How CFRB-FM built its stereo system, Clive Eastwood ..... Dec. 44

Paper tape control permits automatic programming of radio stations, Glen A. Robitaille ..... Apr. 45

Radio must meet the challenge of listeners' changing needs, D. C. Trowell ..... Apr. 38

Survey shows broadcasters' needs, Harold Price .. Apr. 36

The evolution of the package, J. R. Simpson .. Apr. 41

These specifications govern stereo broadcasting in Canada ..... Dec. 46

Circuit Theory

Cascaded transistors produce high voltage pulses, F. C. Creed ..... Mar. 51

Correction of non-linear distortion in transistor amplifiers, G. W. Holbrook and E. P. Todosiev Oct. 35

Efficient three-phase supply powers Xenon arc discharge lamps, M. P. MacMartin and F. R. Lipsett ..... Oct. 42

Growth and decay in electrical circuits, W. H. Sheppard ..... May 42

Hybrid parameter simplifies calculation of transistor current gain versus load, M. A. Gullen ... Feb. 48

Low impedence thermoelectric device powers tunnel diodes, E. L. R. Webb and J. K. Pulfer ... Feb. 40

New approach simplifies the design of transistor amplifiers, H. L. Armstrong ..... Nov. 41

Phase-locked oscillator circuit divides mean period of input signal, P. G. Hodgson ..... Sept. 94

Regulator circuit improves operation of CdS sunswitch, S. A. Gardiner ..... July 34

Switching ac with transistors, J. Leng ..... Oct. 46

The operation of linear diode detectors, J. K. Pulfer ..... Nov. 46

Communications Systems

Oblique ionospheric sounding improves communication system performance, Harold Price ..... Aug. 28

Component Parts

New button mica capacitors feature good UHF performance up to 125C, G. C. Robinson .... Aug. 25

Electron Devices

Design curves aid proper utilization of thermoelectric devices, A. Gelbtuch and C. A. A. McPhee ..... Feb. 32

Semiconductor materials provide key to thermoelectric developments, R. P. Poslawski ..... Feb. 29

The development of thermoelectric materials for refrigeration, C. A. A. McPhee ..... Feb. 36

Electronic Computers — Issue Page

Business machine reads census forms, Richard J. Gwyn ..... Aug. 31

Engineering Management

Electronic circuits explain the Webber principle of scientific management, A. P. Harris ..... Oct. 45

PAs form group to keep up with trends, M. Woelfle ..... Sept. 93

Industrial Electronics

Electronics speeds freight car sorting ..... Aug. 34

Soviet industries make increasing use of electronic control techniques, Vladimir E. Nize ..... Aug. 38

Thermoelectric cooling improves baffles for vacuum pumps and systems, R. P. Poslawski ..... Feb. 37

Information Theory

Information theory paves way to new developments in communications, Douglas A. Carruthers ..... Dec. 35

Instrumentation

New facility tests special purpose tubes, H. Price . Apr. 54

New floating labatory facilitates underwater acoustic measurements, G. W. McMahon ..... Feb. 44

Thermoelectricity permits new design concepts in cooling equipment, James Keane ..... May 48

Microwave Theory and Techniques

Simple holders for crystal detectors feature low VSWR, high sensitivity, A. Staniforth and J. K. Pulfer ..... July 31

Solid state devices change economics of microwave systems, John E. Raftis ..... Dec. 52

Nuclear Science

Scientists discuss nuclear structure, H. E. Gove .. Mar. 48

Radio Frequency Interference

TV receiver radiation interferes with AM reception ..... Apr. 40

Space Electronics and Telemetry

Canada's top-side sounder satellite will probe ionosphere next year, Richard J. Gwyn ..... May 46

Feature Reports

Canadian firm expands facilities for rebuilding picture tubes (Industrionics (Canada) Ltd.) ... Nov. 55

Collins Radio Co. of Canada continues expansion with opening of new plant ..... July 36

Components and Equipment Directory ..... June 99

Defence electronics procurement topped $133 million in 1960 ..... Aug. 32

Directorate of industrial research will promote development in Canada ..... Nov. 35

EIA annual meeting focuses attention on problems of electronics industry ..... July 25

EIA forms committees to study research, exports Oct. 33

Electronic imports from U. S. and U. K. increased again in 1960 ..... July 28

Government and industry must reappraise their positions on military components (report of Canadian Military Electronics Components Symposium) ..... May 53

IRE Canadian Electronics Conference (preview) . Sept. 65

IRE Canadian Electronics Conference (report) .. Nov. 52

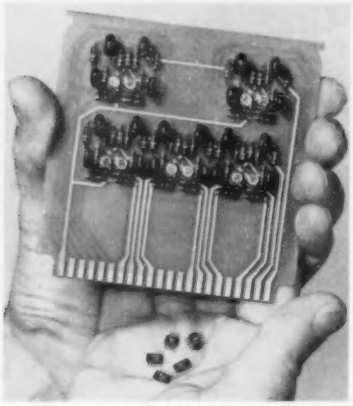
ISA International Instrument-Automation Conference and Exhibit (preview) ..... May 38

Industry Review and Forecast 1960-61 ..... Jan. 26

New Products Review ..... Mar. 38

Wide range of new equipment is used in Canada's television stations ..... Apr. 50

New solid state devices enter market (report of IRE International Convention) ..... May 51



Solid Circuit networks 116

Series 51 Solid Circuit (R) semiconductor networks include six different digital circuit modules. They will handle 90% of the circuit functions of digital equipments, particularly for military computers, programmers and other information processing applications. The networks perform flip-flop, counter, NOR gate, NAND gate, and OR gate functions. Each silicon network is contained in an hermetically-sealed package measuring only ¼ x ⅛ x 1/32 of an inch.

A digital computer was demonstrated recently in which 587 digital circuits occupied a total volume of only 6.3 cubic inches and weighed only 10 ounces.

Texas Instruments, Inc., Rexdale, Ont.

Ten-turn precision potentiometer 117

Model 3500 precision potentiometer has a molded, all-plastic case plus shaft seal which provide resistance to humidity. Standard models exceed steady-state humidity requirements; units to meet the cycling humidity requirements of MIL-STD-202B, Method 106 are available at only a 10% premium in price.

Standard resistance is 500 to 125 k; special resistances up to 250 k. Resolution is 0.03 to 0.01%. Linearity is ±0.25% standard. Power rating is 2 watts at 70 C. Operating temperature range is —65 C to +125 C. Size is ⅞ in. dia. x 1 in. long.

Bourns (Canada) Ltd., Toronto.

Miniature round connector 118

Bantam miniature round connector conforms to the requirements of MIL-C-0026482A (WEP). Connectors are supplied with a variety of insert configurations in nine shell sizes. Bantam plugs and receptacles feature the Tri-Lok bayonet coupling, a positive coupling which can be disconnected quickly. They provide an interfacial seal, per the military spec and the need for safety wiring is eliminated by the positive locking bayonet coupling. Polarized inserts and a five point key and keyway eliminate the possibility of mismating.

Burndy Canada Ltd., Scarborough, Ont.

Low-voltage geiger tubes 119

The 480 series geiger tubes feature unusually-low operating voltage of 480 volts. The gas filling and processing have been developed in cooperation with Atomic Energy of Canada Ltd. Advantages of the new tubes are: (a) less expensive components may be used in instruments; (b) increased reliability of the instrument; (c) circuit simplification in instruments for detection and measurement control, due to the large output pulses developed by the new tubes; (d) the tubes are suitable for both pulse counting and current operation.

Electronic Associates Ltd., Willowdale, Ont.

(Continued on page 68)

HEADSET AND MICROPHONE COMBINATION

A COMMUNICATIONS REVOLUTION!

SHARPE Noise-Excluding Circumaural Earphones with Close-Talking Boom-Mounted Microphone

Wherever noise makes communications a problem, Sharpe's new Earphone-Microphone combination is the answer. Ideal for use in everything from helicopters to Language Labs! Guaranteed to outperform comparably priced units, in any application!

- *Circumaural Earphones exclude —40db ambient noise!*
- *Response is completely flat from 30 to 10,000 c.p.s.*
- *Exceptionally comfortable. Liquid-filled Ear Pads removable for washing!*
- *Close-Talking Microphone suppresses up to —43db noise from a source at 4 feet!*
- *Excellent response from 15 to 15,000 c.p.s.*
- *Microphone element floats in foam. No noise pickup from touching boom!*

Learn how this outstanding Earphone-Microphone unit can solve your communications problems. Write for free brochure to—

E. J. SHARPE INSTRUMENTS OF CANADA LIMITED

6080 YONGE STREET, WILLOWDALE, ONTARIO. BA. 1-8733

For further information mark No. 66 on Readers' Service Card

The graphic arts promote Canadian designers

Canadian periodicals are a showcase for their work

The graphic arts employ more designers, artists and craftsmen than any other business or industry.

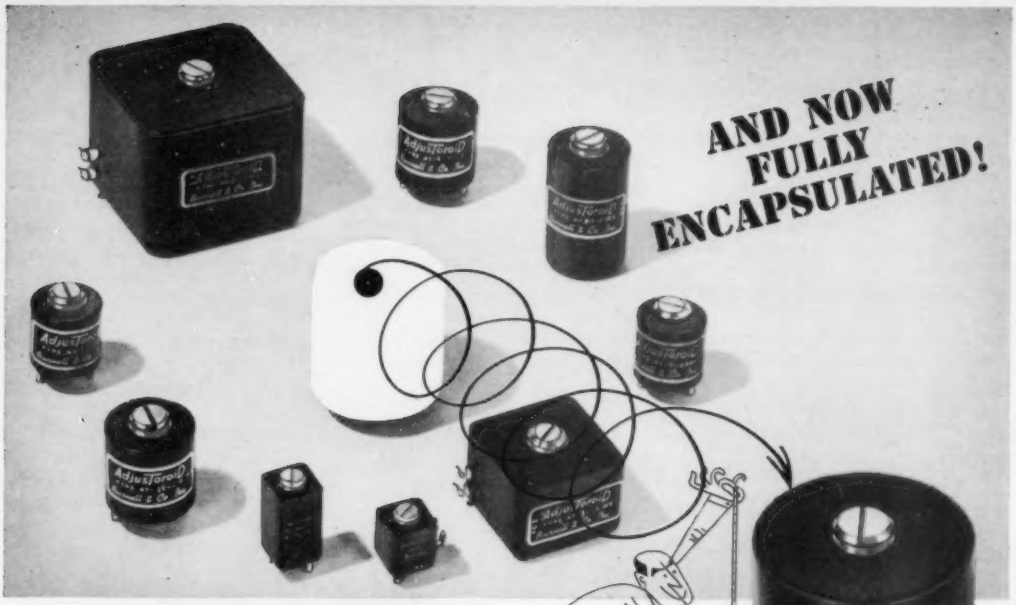
Defined in a submission to The Canada Council as "the creative and interpretative aspects of art and design in relation to all forms of printed communication", and so touching the life of the whole people, the graphic arts derive their main stimulus and support from the Canadian print media.

In these you see the best work of thousands of artists, photographers, typographic designers, and printing craftsmen.

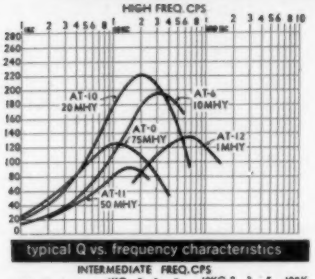
As Canada's leading publisher of national magazines, business and financial periodicals, Maclean-Hunter is the nation's principal showcase of the graphic arts . . . a vital part of the Canadian way . . . the best way for Canadians.

MACLEAN-HUNTER **PUBLISHING CO. LTD.**

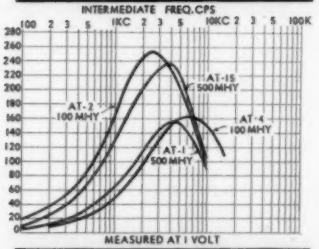
Head Office—481 University Avenue, Toronto 2 • 1242 Peel Street, Montreal 2 • 1030 W. Georgia Street, Vancouver 5



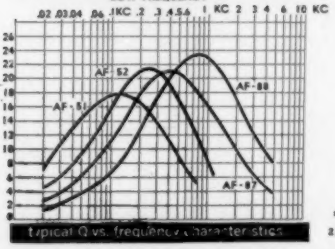
NEW SUBMINIATURE BURNELL ADJUSTOROIDS* HANDLE BIG JOBS



typical Q vs. frequency characteristics



typical Q vs. frequency characteristics



typical Q vs. frequency characteristics

*PAT. 2,742,020

The new subminiature **Burnell Adjustoroids** utilizing an ingenious patented method of magnetic biasing cover a wide range of frequencies, occupy less space and are available at low cost.

New **Burnell Adjustoroids** possess all the outstanding characteristics of non-adjustable toroids including:

Precise continuous adjustment of inductance over a 10% range.

No need for external control current.

Hermetic sealing to meet Government MIL E # 15305-A specifications.

If your adjustoroid needs can't be met from our stock catalogue, we'll be glad to manufacture to your specifications.

	Length/ Dia.	Width	Hgt.	Wt.	Useful Freq. Range	Max Q	Max L in hys
AT-0	1 1/16		1"	2 oz	1 kc to 20 kc	10 kc	3 hys
AT-1	1 3/4	1 3/4	1 1/4"	7.25 oz	2 kc to 10 kc	4 kc	15 hys
AT-2	2 3/4	2 3/4	2 1/4"	24 oz	Below 2.5 kc	2.5 kc	125 hys
AT-4	1 13/64		1 1/4"	4 oz	1 kc to 16 kc	6 kc	15 hys
AT-6	1 1/16		1"	2 oz	10 kc to 100 kc	30 kc	.75 hys
AT-10	1 13/64		1 1/4"	4 oz	3 kc to 50 kc	20 kc	.75 hys
AT-11	45/64	45/64	3/4"	.83 oz	2 kc to 25 kc	15 kc	5 hys
AT-12	45/64	45/64	3/4"	.83 oz	15 kc to 150 kc	60 kc	.5 hys
AT-15	1 21/32		1 7/8"	14 oz	Below 5 kc	4 kc	125 hys
AF-51	1 13/64		2"	5 oz	30 cps to 500 cps	120 cps	1000 hys
AF-52	1 13/64		2"	5 oz	50 cps to 1 kc	250 cps	1000 hys
AF-87	45/64	45/64	1 1/4"	1.7 oz	90 cps to 2 kc	400 cps	80 hys
AF-88	45/64	45/64	1 1/4"	1.7 oz	.16 kc to 4 kc	800 cps	42 hys

Manufactured and Sold in Canada by
Edo (Canada) Limited
P.O. Box 97
Cornwall, Ontario, Canada
Phone: WEllington 2-6774

SALES REPRESENTATIVE:
A. Deskin Sales Company, 1091 Shorecrest (14th) St., St. Martin, Montreal 40, P.Q. Phone MUrray 1-0201; MUrray 1-8645

For further information mark No. 30 on Readers' Service Card

Chemical Institute of Canada sponsors computer study project

A project to study the implications of computers and to convey information on computer techniques to industry has been started by the Chemical Engineering Div. of the Chemical Institute of Canada.

This Machine Computation Project, under co-ordinator A. I. Johnson of McMaster University, aims at assisting chemical engineers in industry and university in keeping up-to-date in the rapidly changing areas of machine computation, simulation and optimization. The project will do this by organizing workshops, sponsoring university research, producing technical films and by publishing articles.

Dr. Johnson has already started producing a sound film, "An introduction to the electronic analog computer," which will be available to universities and industry.

IFAC elects new council and seeks papers

The executive council of the International Federation of Automatic Control (IFAC) was newly elected by the 26 national organizations on November 1. Prof. E. Gerecke (Zurich) was elected president, and Mr. J. F. Coales (Cambridge) and Prof. P. J. Nowacki (Warsaw) were elected vice-presidents. Prof. A. M. Letov (Moscow) becomes past-president. Prof. J. C. Gille (Paris), Dr. J. C. Lozier (Whippany, N.J., USA) and Academician Gr. Moisil (Bucharest) were elected ordinary members of the executive council.

The technical committees of IFAC are preparing the 2nd International Congress on Automatic Control to be held September, 1963, in Basle on the invitation of the Swiss Association for Automatic Control. It is hoped to continue the exchange of ideas on fundamental theory and on applications of automatic control which met with such success at the 1st Congress of IFAC held in Moscow, 1960. Authors intending to present papers at the Congress are requested to contact the Canadian member organization of IFAC: The Secretary, Associate Committee on Automatic Control, National Research Council, Ottawa 2.

System monitors patients continuously

A Body Function Recorder, developed by Honeywell's Medical Systems Div. in co-operation with Mayo Clinic, Rochester, N.Y., automatically monitors temperature, pulse rate, respiration and diastolic and systolic blood pressures of a dozen or more hospital patients — all at the same time.

It is designed to provide permanent records of patient condition, measured every two minutes, and to immediately sound an audio-visual alarm if any of the five variables reaches a preset dangerous stage.

Three transducers are used. The blood pressure and pulse transducer is a "clothespin" type earpiece that slips lightly over the upper portion of the ear. The temperature transducer is a small clip that is inserted into the corner of the mouth. The respiration transducer is an air-flow detector about the size of a silver dollar. It is positioned in front of the mouth and under the nose and is held in place by a light, pliable support.

You can place the utmost confidence in Dale precision resistors even when today's new and unprecedented standards of "missile reliability" are the goals towards which you are designing.

Under any and all conditions, Dale resistors retain their stability because it has been "firmly infixed" by Dale design and methods of manufacture . . . methods which have now reached new levels of achievement as part of Dale's super-high reliability development program.

SPECIAL PROBLEMS? Let us help you with your requirements for special resistance products. We make modifications of standard products, resistor networks, matched pairs, etc. Send us your specs.

PROMPT DELIVERY. Whether your need is for a short "test run" or a large production release, Dale offers prompt service, direct from the factory and through a widespread network of distributors.

Write for Bulletins R-23, R-25 and R-30 with handy cross-reference file cards

DALE ELECTRONICS CANADA LTD.
18 Howden Rd., Scarborough, Ont.

DALE TYPE RS RESISTORS
WIRE WOUND • PRECISION • POWER

Designed for advanced electronic circuits where space is at a premium. Three configurations: Type RS with axial leads and in most ratings and resistances shown; Type RLS with radial leads; Type RSE for clip mounting.

- Rated at ½, 1, 2, 2½, 3, 5, 7, 10 watts
- Resistance range from .05 ohm to 175K ohms, depending on type
- Tolerance 0.05%, 0.1%, 0.25%, 0.5%, 1%, 3%
- Temperature coefficient within 0.00002/degree C.
- Operating temperature range from —55° C. to 275° C.
- Smallest in size, ranging from 5/64" by 5/16" to 3/8" by 1-25/32". Ten choices
- Completely protected, impervious to moisture and salt spray
- Complete welded construction from terminal to terminal
- Silicone sealed, offering high dielectric strength and maximum resistance to abrasion
- Meet functional requirements of MIL-R-26C

A Subsidiary of DALE ELECTRONICS INC., Columbus, Neb., U.S.A.

For further information mark No. 27 on Readers' Service Card

G. A. Woonton elected delegate and director of IRE

Garnet A. Woonton, Macdonald Professor of Physics, Director of Eaton Electronics Research Laboratory and Chairman of the Department of Physics, McGill University, has been elected a Delegate - at - Large/ Director-at-Large of the Institute of Radio Engineers for 1962-64.

Prof. Woonton was born in London, Ont. in 1906. He entered the University of Western Ontario in 1922 and was awarded the BA degree in Commercial Economics in 1925. After a few years with the Bell Telephone Co. of Canada, and a short time at the University of Chicago, he returned to UWO and was granted the MA degree in physics in 1931. In 1955 he was given a DSc (Hon.) by that University.

From 1931 to 1939 Prof. Woonton held the joint appointment of Research Fellow in the Dept. of Physiology and Demonstrator in the Dept. of Physics at UWO. During that period he worked with a group concerned with the physiology of the cerebral cortex; in the Physics Dept. he carried on research on the diffraction of electrons.

With the advent of the war in 1939, he became a full time member of the Dept. of Physics and a member of the team working with NRC on the development of radar.

In 1948 he moved to McGill University where he was appointed Prof. of Physics. In 1950, he was appointed Director of Eaton Electronics Research Laboratory, and in 1955 became Macdonald Professor and Chairman of the Dept. of Physics.

After the war he became interested in analogies between optics and the properties of microwave radiation, in the interaction of electrons in long electron beams and in the mechanisms responsible for the generation of noise in beams at microwave frequencies. During the same period he was a member of one of the teams engaged in the development of the prototype of the Mid-Canada radar line, and was also a member of the team organized at MIT by the U. S. Navy to look into problems of air defense of North America.

During the past five or six years, Prof. Woonton's research has centred in the subjects which are sometimes called quantum electronics.

Prof. Woonton was elected a Fellow of IRE in 1951. He has served as student representative of IRE at UWO, as a member of the Education Committee (1945-46) and as chairman of the London Section (1945).

In the International Union of Scientific Radio, he served as International Chairman of Commission VII (Electronics) from 1952-57, and was elected vice-president of the Union in 1957, a position which he still holds.

He is a past president of the Canadian Association of Physicists (1948-49), a member of the American Physical Society and a member of Sigma Xi. He was elected a Fellow of the Royal Society of Canada in 1950.

New Professional Group approved for Toronto

IRE Headquarters has approved the Toronto section application for the formation of a Joint Chapter of the Professional Groups of Antennas and

(Continued on page 66)

PAYETTE
Presents...

STENTOR COLUMNS

Stentor enclosures started being marketed in France in 1951. Everyone is familiar with these columnar loudspeaker enclosures which are used everywhere, in churches, exhibitions, public meetings, theatres, etc.

But many people are unaware of the "exciting" characteristics of the Stentor enclosures and use them as regular loudspeakers.

BOUYER COLUMNS WILL OUTPERFORM ANY CONVENTIONAL SPEAKER

INSTITUTIONS	BANKS	EXHIBITS
PLACES OF WORSHIP	SUPERMARKETS	LOUNGES
AUDITORIUMS	HOTELS	PARKS
HOSPITALS	NIGHT CLUBS	FACTORIES
ARENAS	RINKS	RESTAURANTS
FUNERAL HOMES	LOBBIES	

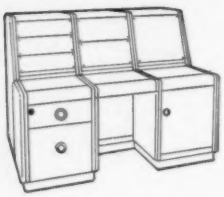
WRITE FOR FREE LITERATURE TO:—

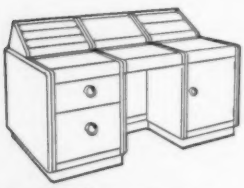
PAYETTE RADIO LTD.

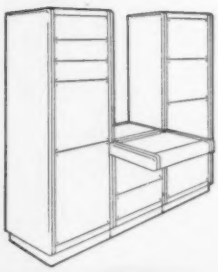
730 ST. JAMES ST. W. MONTREAL 3
UN 6-6681

For further information mark No. 47 on Readers' Service Card

EMCOR® STANDARD CABINETS







- Cut enclosure design time. Select your packaging needs from a complete line of standard and heavy duty EMCOR Cabinets.
- EMCOR MODULAR ENCLOSURE SYSTEM Cabinetry provides for thousands of control center combinations.
- Choose from hundreds of EMCOR Cabinet widths, depths and heights offering an exclusive combination of engineered features.
- Engineered simplicity of basic frames and components affords quickest and easiest erection of control center assembly.
- EMCOR Cabinetry Engineers backed by the research and development "know-how" of the Roy C. Ingersoll Research Center set the pace for the packaging needs of electronics, instrumentation and electro-mechanical engineers from coast to coast.
- Rugged frame construction surpasses all standard requirements for increased load carrying capacities.
- Compatible cabinet design assures simplified and economical expansion at any time.
- EMCOR Cabinet manufacturing meets rigid quality-controlled craftsmanship standards.

Condensed Version of Catalog 106 Available Upon Request.

Originators of the Modular Enclosure System

INGERSOLL PRODUCTS

Division of Borg-Warner Corporation

1000 W. 120th ST. • DEPT. 1249 • CHICAGO 43, ILLINOIS

QUALITY EMCOR PRODUCTS — INGERSOLL B-W PRODUCTS — BORG-WARNER

Represented in Canada by Brian Engineering Limited, 5275 Van Horne Avenue, Montreal 29, P.Q., Phone: RE. 7-2800; 2773 Dufferin Street, Toronto 19, Ont., Phone: RU. 7-5441

For further information mark No. 32 on Readers' Service Card

Propagation, and Microwave Theory. At an earlier meeting in Toronto, Dr. J. L. Yen, Assistant Professor, Electrical Engineering Dept., University of Toronto, had been elected to head the new group. Dr. Yen, who is the U of T Student Branch Representative on the Toronto Section executive committee, had done most of the organizing for the new Chapter.

Ottawa Section member elected Fellow of IRE

Paul A. Redhead, National Research Council, Ottawa, was the only Canadian member of IRE elected a Fellow this year. He won his honor "For contributions to the field of electron devices and to ultra high vacuum technology."

Mr. Redhead comes from England where he took a BA degree at Cambridge in 1944. He worked with the British Admiralty from 1944-47, then joined the National Research Council staff in Ottawa. He is in charge of the Electron Physics Group of the Radio and Electrical Engineering Div.

Canadian Region Gold Medal is proposed

At its meeting in Toronto on October 2, the Canadian Region Committee discussed the possibility of establishing a Canadian Region Gold Medal to be awarded members of IRE in Canada for outstanding contributions in the field of electronics.

B. R. Tupper, Director of the Canadian Region will select a working committee to develop ground rules for the award and prepare a report for presentation at the next Canadian Region meeting to be held in New York in March, 1962.

Student Paper Competition

The Canadian Region Committee unanimously voted to continue the student paper competition, and to seek ways of promoting greater interest in the annual event. Dr. A. D. Moore, chairman of the Canadian Region Education Committee reported that results of the current paper competition will be released before the end of the average Section year (about April).

Recognition of schools

During the past year there has been increased interest in the matter of approving educational organizations for the purpose of establishing

student associate members and branches. At the present time, the Educational Committee of IRE (Primarily U. S. members) grants approval, and a case arose last year where approval was given without prior consultation with the Canadian Region Committee.

Director Tupper has been asked to take a motion to the Board of Directors' meeting in New York, "that the Canadian Region Committee approves the policy for the establishment of student associate branches in Canada, provided that prior approval is given by the Canadian Region Educational Committee."

New Student Associate Branches

The B. C. Vocational School has been granted Student Associate Membership in IRE. About 50 day and night school students have applied for membership, and officers were elected at an inaugural meeting November 8. Mr. R. E. Ridsdale of the Electronics Dept. is the representative on the Vancouver Section executive committee.

DeVry Technical Institute of Canada Ltd., Toronto, has just been granted a charter for a Student Associate Branch IRE Headquarters. L. F. T. Gent, educational director at DeVry has been appointed the representative. Elections have been held for the Branch executive and a drive is under way to increase their present membership of 60 at the school.

Section meetings

Toronto: Jan. 8, 1962; Tour of the Electronics Div. of Ferranti-Packard Electric Ltd., Toronto.

Vancouver: Dec. 18; "Modern oscilloscopes" and "High-speed oscilloscopes" by O. Svehaug and C. Moulton, Project Engineers, Instrument Design Dept., Tektronix, Inc.

When EIA and IRE held its annual golf tournament in Toronto recently, G. Mansour, left, of RCA Victor and K. Brands of Mallory Battery were able to compare two top trophies.

22 years of experience in designing and producing laboratory-type Electronic Voltmeters has made possible this Ballantine Model 300-G.

This is the most precise instrument in our entire line of sensitive wide-band Electronic Voltmeters.

BALLANTINE Model 300-G SENSITIVE ELECTRONIC VOLTMETER

Price $315

- Top accuracy of 1% over entire meter scale from 1 mv to 250 v and over the band of 20 cps to 20 kc. Better than 2% to 1,000 volts and for the wider band of 10 cps to 250 kc.
- High input impedance: 2 megohms shunted by 15 pF, except 25 pF on lowest voltage range.
- Long life: Several thousands of hours of operation without servicing or recalibration.
- Does not require stabilized input voltage. Less than ½% change in indication with power supply change from 105 v to 125 v.
- Five inch, mirror-backed, easy-to-read meter. Only two scales with mirror between. One is 1 to 10 for volts, and the second is 0 to 20 for decibels.

Also available in 19 inch relay rack Model 300 G-S2 at $325.

Write for brochure giving many more details

— Since 1932 —

BALLANTINE LABORATORIES INC.

Boonton, New Jersey

CHECK WITH BALLANTINE FIRST FOR LABORATORY AC VACUUM TUBE VOLTMETERS, REGARDLESS OF YOUR REQUIREMENTS FOR AMPLITUDE, FREQUENCY, OR WAVEFORM. WE HAVE A LARGE LINE, WITH ADDITIONS EACH YEAR. ALSO AC/DC AND DC/AC INVERTERS, CALIBRATORS, CALIBRATED WIDE BAND AF AMPLIFIER, DIRECT-READING CAPACITANCE METER, OTHER ACCESSORIES. ASK ABOUT OUR LABORATORY VOLTAGE STANDARDS TO 1,000 MC.

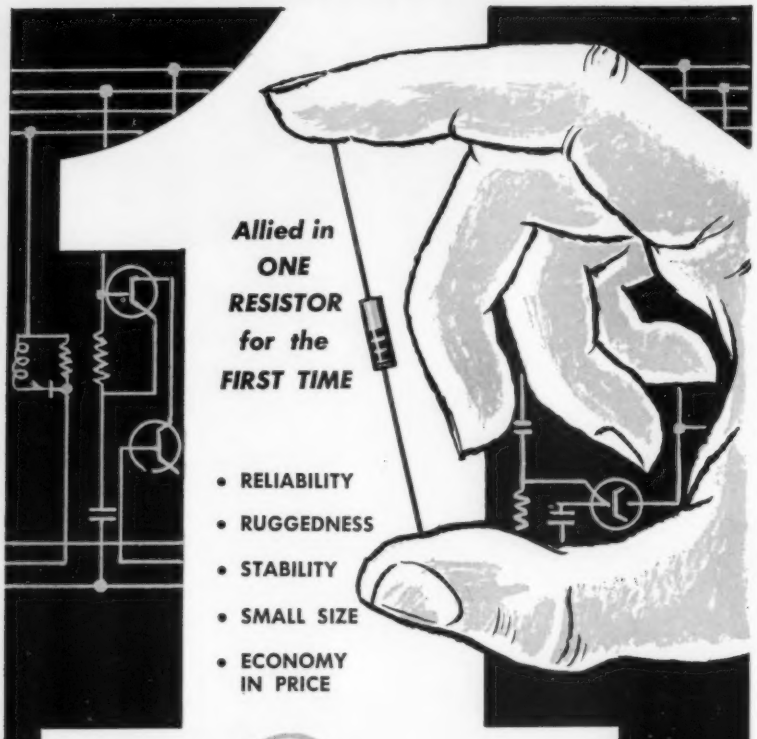
Represented by Bayly Engineering, Ltd., First Street, Ajax (Toronto), Ontario, Canada

For further information mark No. 19 on Readers' Service Card

METOX

TYPE F-20

MINIATURE MOLDED OXIDE RESISTORS



Welwyn

RELIABILITY — Failure rate is better than one per ten million hours.
STABILITY — Under full load, the stability is better than 2% after 10,000 hours. Subsequent rate of change will not exceed 0.1% per thousand hours.
TEMP. COEF. — Will not exceed ± 0.05% per °C.
NOISE — Less than 0.5 uV/V applied.
TOLERANCE — All MIL-R-11C values at ± 5%.
SIZE — Same as the Mil Type RC20.
SPECIFICATION — Exceeds materially Mil-R-11C.
PRICE as compelling as the performance and related to 5% carbon composition resistors.

Type	Rating @ 70°C Ambient	Mil Type	Rated Voltage	Minimum Resistance	Maximum Resistance	Dialetric Strength
F20	½ Watt	RC20	350V	10 Ohms	500 K	1000 Volts

For complete data and specifications write to

Welwyn Canada Limited

1255 BRYDGES STREET, LONDON, ONTARIO

For further information mark No. 64 on Readers' Service Card

New instruments—cont.

Tuned amplifier-null detector 120

Type 1232-A tuned amplifier and null detector is a low-noise, transistor amplifier with 1-uv full-scale sensitivity, which tunes continuously from 20 cps to 20 kc, with additional fixed-tuned frequencies of 50 kc and 100 kc. It is intended primarily as a bridge detector, but has other applications, among them the detection of high-frequency modulated signals (with a crystal demodulator), approximate wave analysis at audio frequencies and as a preamplifier for transducers.

Continuous tuning is provided by an RC null circuit which has only a single variable element, a potentiometer with a total range of 40 db. With the GR type 1632-A inductance bridge, this null detector makes possible inductance balances to a resolution of 1 part in 10^4.

General Radio Company, Toronto.

Instrument locates vital heart tissue 121

A simple method of locating vital heart tissue—the "bundle of His" — during open heart surgery, and thus minimizing the chance of surgically induced heart block, has been developed by Medtronic, Inc. Known as the Conduction System Locator, the instrument consists of an electronic depth probe which is a pencil-like probe affixed to a tone box. When the probe is passed

over the ventricular septum, the tone changes pitch as contact is made with the "bundle of His". By moving the probe back and forth across this area, the tone-change traces the "bundle's" location with an accuracy of one millimeter.

Canadian Biotronics Corp. Ltd., Montreal.

Multiple chart recorder 122

Keinath K-Loggers are capable of simultaneously recording and displaying

up to 400 variables on 100 separate charts, in 4 colors. The units produce continuous, two-coordinate graphs indicating any values which can be measured by an electrical signal. The K-Logger utilizes solenoid-actuated print-hammers and typewriter ribbons to produce permanent records of multiple processes. A wide range of standard time scales is available.

Industrial Measurements Ltd., Don Mills, Ont.

Solid state counter 123

Erie-Pacific model 925 is a solid-state 20 Mc counter-timer. It offers counting of periodic or random electrical events and measurement of frequency, period and time intervals. A built-in memory provides readout storage, continuous display while counting, more frequent sampling and less operator eye fatigue. The memory operates for all eight digits of the in-line Nixie readout.

Measurement and Control Engineering Ltd., Scarborough, Ont.

Data recording system 124

A rugged data recording system that weighs 25 lbs with all the associated electronics and only 50 lbs with complete waterproof casing has been developed by Leach Corp. The system is capable of withstanding severe environments. It records FM data on a 14-track, one-inch tape.

Brian Engineering Ltd., Montreal.

(Continued on page 72)

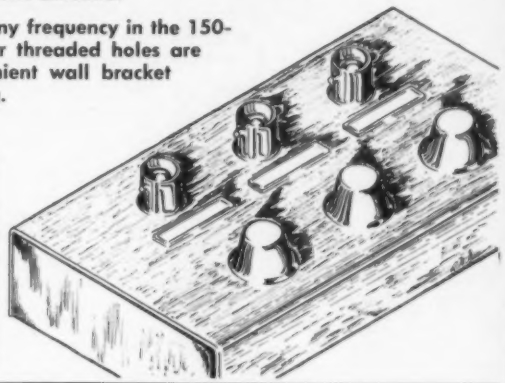
PRESS TO TALK?

NOT AFTER YOU INSTALL THE NEW J-150-2X MOBILE DUPLEXER BY SINCLAIR

The MODEL J-150-2X DUPLEXER is a low cost lightweight filter which permits simultaneous transmission and reception on one antenna.

It can be tuned to any frequency in the 150-174 Mc. band. Four threaded holes are provided for convenient wall bracket or cabinet mounting.

Isolation Rx to Tx at Tx frequency	45 db at 5 Mc. sep.
Isolation Tx to Rx at Rx frequency	25 db
Power Rating	30 watts continuous
Insertion Loss at Tx frequency	0.5 db
Insertion Loss at Rx frequency	0.8 db
Impedance Level	50 ohms
Dimensions	2" x 4" x 6"
Weight	1.5 lbs.



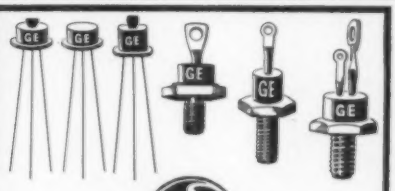
FOR ADDITIONAL INFORMATION PHONE WRITE OR WIRE

SINCLAIR RADIO LABORATORIES LTD.

21 TORO RD. DOWNSVIEW ONTARIO

For further information mark No. 55 on Readers' Service Card

for immediate delivery of GENERAL ELECTRIC TRANSISTORS AND RECTIFIERS call YOUR AUTHORIZED GENERAL ELECTRIC DISTRIBUTOR



Also Western Distributors for semi-conductor component lines by VECTOR USECO and WATERMAN

—ELECTRONIC JOBBERS—

COMPLETE STOCKS CARRIED

Smalley's RADIO LTD.

1105 - 7th Ave., S.W., Calgary, Alta.

FLASH! ALL ORDERS SHIPPED ON DAY RECEIVED

For further information mark No. 56 on Readers' Service Card

ALL CANADA OVERNIGHT

YOU CAN DEPEND ON MILGRAY/NEW YORK FOR OVERNIGHT DELIVERY ANYWHERE... OF SEMICONDUCTOR PRODUCTS FROM THESE OUTSTANDING MANUFACTURERS:

BENDIX
COLUMBUS
ERIE
GEMCO
GENERAL ELECTRIC
GENERAL INSTRUMENT
GENERAL TRANSISTOR
HOFFMAN
KEMTRON
MICROWAVE ASSOCIATES
MOTOROLA
NATIONAL SEMICONDUCTOR
NORTH AMERICAN
OHMITE
PHILCO
SARKES-TARZIAN
SPRAGUE
TUNG-SOL
TEXAS INSTRUMENTS
UNITED COMPONENTS
WESTERN TRANSISTOR
WESTINGHOUSE

MILGRAY / NEW YORK
160 Varick Street / New York City 13 / YUkon 9-1600
Zenith numbers in leading industrial areas
TWX-NY1-4013/TELEFAX-FQF

For further information mark No. 44

CAMESA NEWS

This bulletin has been prepared for CEE by the Specifications Division, Canadian Military Electronics Standards Agency, Ottawa.

› Specification MIL-W-27300A(USAF), covering polytetrafluorethylene-insulated copper wire rated for continuous operation at 260 C, has been adopted by the RCN and the RCAF. It supersedes MIL-W-27300(USAF) and incorporates a number of changes in requirements.

› Extensive revisions appear in specification MIL-C-3098C, covering quartz crystal units. This specification has been adopted by the Canadian Armed Forces, and supersedes MIL-C-3098B and MIL-C-19374 (Ships). The Canadian Notice of Adoption for MIL-C-3098C requires Qualification Approval in place of Preproduction Inspection, and also reduces the number of permissible failures. Also issued with MIL-C-3098C are 40 detail specifications covering individual crystal units.

› The Canadian Armed Forces have recently adopted specification MIL-C-20D, covering fixed temperature compensating ceramic dielectric capacitors. This specification supersedes MIL-C-20C and incorporates a number of changes. Among them are an increase in temperature range for insulated types to—55 through +125 C, and increases in initial insulation resistance. The insulation resistance has also been increased at high ambient temperature and after life, temperature and immersion cycling, vibration and moisture resistance tests. Six new detail specifications have been added covering styles CC60 through CC71, having a temperature range of —55 to +150 C.

› Specification MIL - R - 22097(NAVY), covering variable trimmer resistors, has been superseded by MIL-R-22097A (NAVY). The revised specification has been adopted by the Canadian Armed Forces. Significant changes include reduction of the maximum no-load temperature from 225 to 175 C, and the addition of two new styles rated at 1 watt. The wattage rating of two of the original styles has been reduced, but they are available in more resistance-temperature characteristics. A new temperature characteristic provides full-load rating at 125 C; the previous full-load rating was 70 C.

Defence contracts

Unclassified electronics contracts for $10,000 or more have been awarded to the following Canadian firms by the Department of Defence Production. A figure in parentheses indicates the number of contracts, the amount being the total value.

October 1-15, 1961

› Bell Telephone Co. of Canada, Ottawa, installation of telecommunication equipment and associated on-base cabling, $134,870 (2); lease of communication circuits, $182,548 (4).

› Canadian Admiral Corp. Ltd., Port Credit, Ont., radar test sets, $84,720 (2).

› Canadian General Electric Co. Ltd., Toronto, components, $44,946.

› Canadian Marconi Co., Montreal, test sets, $45,104; dismantling of radio transmitter and associated drive and test equipment, $17,923.

› Canadian National Railways Co., Ottawa, lease of communication circuits, $107,206 (3).

› Canadian Westinghouse Co. Ltd., Ottawa, tubes, $14,917.

› Collins Radio Co. of Canada Ltd., Toronto, spares for emergency transceivers. $57,736.

› Computing Devices of Canada Ltd., Ottawa, position and homing indicator spares, $281,992; communication sets, $48,305; engineering order handbooks, $48,819; research contracts, $113,500 (2).

› Electric Storage Battery Co. (Canada) Ltd., Toronto, batteries, $73,568.

› Honeywell Controls Ltd., Toronto, spares for automatic flight control system, $476,970; engineering order handbooks, $16,551.

› ITT Electronics Service Co. of Canada Ltd., Montreal, technical representative, $18,000.

› Jerrold Electronics (Canada) Ltd., Toronto, sweep signal generators, $19,245.

› King's Electronics (Canada) Ltd., Montreal, connectors, $18,861.

› Lenkurt Electric Co. of Canada Ltd., Ottawa, radio telephone equipment, $126,606.

› Maritime Telegraph & Telephone Co. Ltd., Halifax, installation of telecommunication equipment and associated on-base cabling, $80,960.

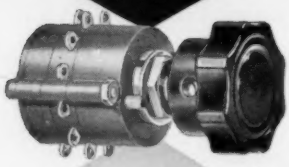
› Micro-Tower Ltd., Scarborough, Ont. antenna tower, $19,498.

› Moffats Ltd., Orillia, Ont., electronic workbenches, $10,601.

› Orenda Engines, Toronto, test cell instrumentation, $23,657.

› Polyfiber Ltd., Renfrew, Ont., fibreglass cases and covers to house electronic equipment, $17,793.

MIDGET TAP SWITCH has giant range



TYPE 3A

Only 1" in diameter . . . weighs 30 grams . . . as many as 8 decks and up to 12 positions per deck. These are among the features of Tech Labs' new all-molded miniature Type 3A tap switch.

Designed for a wide range of military and commercial applications, this single-hole mounted switch has adjustable stops if fewer than 12 positions, single pole, or 6 positions, double pole, are required.

"Shorting" and "non-shorting" types are available and the switch can be furnished solenoid-operated and hermetically sealed.

SPECIFICATIONS

Size: 1" diameter, 1¼" with terminals. First deck, 1-1/16" long. Each additional deck, ½" long.

Weight: First deck, 30 grams. 10 grams for each additional deck.

Rating: 1200 volts rms, 2000 VDC, 5 amps (carrying) 115V.

Insulating resistance: 100 megohms minimum at 500 volts DC.

Life: 1.5 — 2 million revolutions.

Contact resistance:

(standard) 6-10 milliohms.
(silver) 3-5 milliohms.

Temperature range: —65°C to 100°C.

Mounting: Single-hole.

Meets MIL-S-3786 and MIL-E-5272C

TECH LABORATORIES, INC. — **Write for details and prices.**

TECH LABORATORIES OF CANADA

A. Deskin Sales Co.
1091 Shorecrest Ave.
Chomedy, Montreal 40, Quebec
MUrray 1-0201

For further information mark No. 60

- Quebec-Telephone, Rimouski, installation of telecommunication equipment and associated on-base cabling, $109,035 (2).
- RCA Victor Co. Ltd., Montreal, research contract, $24,363; technical representative, $15,252.
- Radionics Ltd., Montreal, transistorized counters, $12,040.

October 16-31, 1961

- Abbey Electronics Ltd., Downsview, Ont., tubes, $57,805.
- Atlas Instrument Corp. Ltd., Toronto, signal generators, $19,164.
- Auto-Lite Batteries of Canada Ltd., Toronto, batteries, $142,321.
- Bell Telephone Co. of Canada, Ottawa, lease of communication circuits, $768,-174 (6); supply and installation of materials for telecommunication plant rehabilitation, $27,116.
- British Columbia Telephone Co., Vancouver, rental of telephone facilities, $78,216 (6).
- Burgess Battery Co., Niagara Falls, Ont., batteries, $29,040.
- Burroughs Business Machines Ltd., Toronto, technical representatives, $60,000.
- CTS of Canada Ltd., Streetsville, Ont., transformer-rectifier degaussing power supplies, $32,700.
- Canada Wire and Cable Co. Ltd., Ottawa, preproduction models of telephone cable assembly, $823,374.
- Canadian General Electric Co. Ltd., Toronto, tubes, $177,883.
- Canadian Marconi Co., Montreal, tubes, $144,431; transmitter equipment, $29,859.
- Canadian Westinghouse Co. Ltd., Ottawa, tubes, $20,393; engineering services related to the evaluation of nonstandard parts, $10,000.
- Computing Devices of Canada Ltd., Ottawa, components, $36,827; technical representative, $16,400; television camera unit, $35,993.
- Conway Electronic Enterprises Ltd., Toronto, reception sets, $23,274.
- E.M.I.-Cossor Electronics Ltd., Dartmouth, N.S., sonobuoy transmitters, $315,240.
- La Tuque Telephone Co., La Tuque, Que., installation of telecommunication equipment and associated on-base cabling, $89,427.
- Litton Systems (Canada) Ltd., Rexdale, Ont., gyro assemblies, $939,945; maintenance spares for inertial navigation system, $570,695.
- Maritime Telegraph & Telephone Co. Ltd., Halifax, installation of telecommunication equipment and associated on-base cabling, $65,545.
- Northern Electric Co. Ltd., Ottawa, submarine cable, $36,653.
- Philco Corp. of Canada Ltd., Don Mills, Ont., automatic number and tape senders, $322,860 (2).
- R-O-R Associates Ltd., Don Mills, Ont., tubes, $30,192.
- Radionics Ltd., Montreal, oscilloscopes, $18,955.
- Sparton of Canada Ltd., London, Ont., sonobuoy transmitters, $311,688.
- Sylvania Electric (Canada) Ltd., Montreal, tubes, $58.375.

FREE!

DESCRIBES MORE THAN 250 TITLES

design, research and production 'tools' that every engineer must have!

Here are just a few of the Rider titles most in demand by engineers coast to coast.

DESIGN OF TRANSISTORIZED CIRCUITS FOR DIGITAL COMPUTERS. *Abraham Pressman, M.S.* **(cloth, $9.95)**

ENCYCLOPEDIA ON CATHODE-RAY OSCILLOSCOPES & THEIR USES (2nd ed. revised & enlarged). *J. F. Rider & S. Uslan.* **(cloth, $27.00)**

BASICS OF DIGITAL COMPUTERS, *John S. Murphy.* **(3 vols., soft cover, $8.40; cloth, $9.30)**

BASICS OF ANALOG COMPUTERS, *Thos. D. Truitt & A. E. Rogers.* **(cloth, $12.50)**

INTERNATIONAL TRANSISTOR SUBSTITUTION GUIDEBOOK (direct substitutions only) *Keats A. Pullen, Jr., Eng. D.* **($1.50)**

VIDEO TAPE RECORDING, *Julian Bernstein.* **(cloth, $8.95)**

UNDERSTANDING MICROWAVES (abridged reprint) *T. J. Young, Ph.D.* **($3.50)**

BASICS OF MISSILE GUIDANCE & SPACE TECHNIQUES, *M. Hobbs, P. E.* **(2 vols., soft cover, $7.80; cloth, $9.00)**

CONDUCTANCE DESIGN OF ACTIVE CIRCUITS, *Keats A. Pullen, Jr., Eng. D.* **(cloth, $9.95)**

CONDUCTANCE CURVE DESIGN MANUAL, *Keats A. Pullen, Jr., Eng. D.* **(stiff cover, $4.25)**

MAGNETIC AMPLIFIERS, Principles and Applications, *Paul Mali.* **($2.45)**

BASIC CARRIER TELEPHONY, *David Talley, E. E.* **(soft cover, $4.25; cloth, $5.75)**

NEW

MAGNETRONS *by Dr. K. Hinkel.* **(hard cover, $3.25)**

ANALYSIS OF BISTABLE MULTIVIBRATOR OPERATION *by P. A. Neeteson.* **(hard cover, $2.90)**

Today, write for FREE 1961 Catalog, Dept. CEE-12

JOHN F. RIDER PUBLISHER, INC.
116 West 14th Street, New York 11, N. Y.
A division of Hayden Publishing Co., Inc.
Canada: Chas. W. Pointon, Ltd.
66 Racine Rd., Rexdale, Ont.

For further information mark No. 53

FOR IMMEDIATE DELIVERY OF G-E TRANSISTORS AND RECTIFIERS CALL

YOUR AUTHORIZED GENERAL ELECTRIC DISTRIBUTOR

ELECTRO SONIC

SUPPLY CO.

543 YONGE ST.
TORONTO
924-9251

For further information mark No. 34

New equipment—cont.

Area weight control systems 125

AccuRay Mark V, Series "E" equipment is the latest design of components for area weight control systems. Remote equipment cabinets, and pedestal, wall mounted and floor mounted operators control stations have been redesigned with every possible production, maintenance and management convenience considered and incorporated. As illustrated,

the equipment cabinets contain all electronic equipment and controls not specifically required in the production area.

AccuRay of Canada Ltd., Montreal.

Recording lathe 126

Fairchild model 740 recording lathe has low wow and flutter—minimum of .03% peak to peak; rumble of —65 db below a 1 kc signal at 5 cm/sec; continuously variable pitch from 100 to 1000 lines per inch which can be operated manually or automatically; three speeds obtained with a belt drive and a two-speed motor; two feed screws—one for the cutter transport and one for the miscroscope travel. The lathe accommodates advance ball or floating cutter.

Eldon Industries of Canada Ltd., Scarborough, Ont.

Alarm system 127

Pilfer Alarm indicates the opening of doors which cannot be locked due to fire regulations. An alarm sounds when a door is opened, and a pilot light indicates which door is involved. Other pilot lights indicate when doors have been opened by authorized persons.

Electronic Watchman Ltd., Toronto.

Audio distribution system 128

Audio-Trol, model AT, is a modulator which can feed five separate channels of audio to any TV distribution system. The new unit eliminates the need for additional audio system equipment and installation in hotels, motels, etc., by utilizing the unused television channels of a standard TV receiver. In this way, AM, FM, background music or public announcements can be added to the TV distribution system.

Jerrold Electronics (Canada) Ltd., Toronto.

CANADIAN MADE

BIW LIMITED

EXTRA FLEXIBLE MOTOR LEADS TRANSFORMER and IGNITION WIRE

VARNISHED CAMBRIC INSULATED CABLE
For use in dry locations. Temperature range to 85°C. Voltages 600 to 5,000. Excellent ozone resistance.

SILICONE MOTOR LEAD WIRE (–40°C to 200°C)
BIW Silicone Motor Lead Wire has a bakeable finish which overcomes the problem of insulation "bursting through" the braid during the baking cycle. No. 24 AWG to 4/0 AWG with single or double glass braid. Dia. over braid from .100" to .800" (MIL spec.). Regular silicone insulated wire from No. 24 AWG on up with concentric stranding, both MIL spec. and commercial types.

NEOPRENE LEAD WIRE (–40°C to 100°C)
Standard Neoprene insulated wire is available with or without weatherproof braid or lacquered braid (for dry location). BIW also makes a double jacketed Neoprene Motor Lead Wire to withstand complete oil submersion.

TEFLON LEAD WIRE (–40°C to 120°C)
Laminated Teflon insulated wire, meeting the need for high temperature cables operating in wet locations and severe conditions, has high dielectric strength and insulation resistance. It is flame-proof, and resistant to corrosive vapours, acids and solvents. Voltage ratings: 600 to 15,000. Outside Dia.: .080" to .250".

FOR ADDITIONAL INFORMATION CONTACT

BOSTON INSULATED WIRE AND CABLE COMPANY LIMITED
HAMILTON, ONTARIO

For further information mark No. 21

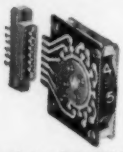
THUMBWHEEL SWITCHES

TABET U.S. Patent 2,841,660

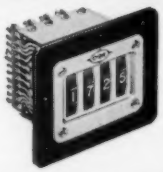
Binary & Digital

- **For Critical Reliability Applications.**
- **Available with internal lighting MIL-L-25467A.**

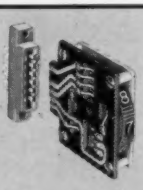
Permanent wafer type, Series TSD-P. Only ½" panel space needed per module. Also available in multi-deck series TM.



Removable wafer type, Series TSD-R. For continuous operation applications where interruptions must be held to an absolute minimum.



Permanent wafer type, Series TSB-P. Available in 8, 10, 12 or 16 positions, up to 36 switches per assembly.



Removable wafer type, Series TSB-R. For applications where maintenance time is valuable and rapid servicing a necessity.

CHICAGO DYNAMIC INDUSTRIES, Inc.

PRECISION PRODUCTS DIVISION
1725 Diversey Blvd., Chicago 14, Illinois
Phone: WEllington 5-4600

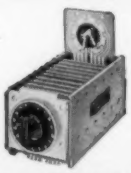
ROTARY SWITCHES

TABET U.S. Patent 2,841,660

- **For Critical Reliability Applications.**
- **Quick changing of programs, configurations, circuits.**
- **Maintenance problems completely eliminated by unique 5-second wafer replacement models.**

1¾" x 1½" Rotary Selector Switch, Series RS15. Manually (illustrated), motor or solenoid operated.

2¼" x 2¾" Rotary Selector Switch, Series RS21. Solenoid, manually or motor operated.



3" x 2½" Rotary Selector Switch, Series RS30. Manually (illustrated), solenoid or motor operated.

4" x 4" Rotary Selector Switch, Series RS40. Motor, manually or solenoid operated.

CHICAGO DYNAMIC INDUSTRIES, Inc.

PRECISION PRODUCTS DIVISION
1725 Diversey Blvd., Chicago 14, Illinois
Phone: WEllington 5-4600

For further information mark No. 25 on Readers' Service Card

Do you have an unsolved "X" spot in your design?

...A place where you would put the "ideal" relay— *if you had it?*

CLARE Type J Relays, *now manufactured in Canada*, have been filling difficult "X" spots in industrial designs for more than a decade.

Possessed of the most positive of all twin-contact designs, the CLARE Type J Relay has all the desirable features of a telephone type relay — yet greatly reduced in bulk.

Many basic design ideas have been improved by this relay — a CLARE original — whose wide acclaim has provoked a lot of imitators but never an equal — whose many distinctive features have provided an eminently satisfactory solution to many perplexing problems involving efficient, long-life relay operation.

Let us work with you to pick the best relay for YOUR important relay requirement by contacting: C. P. Clare Canada Ltd., 840 Caledonia Road, Toronto 19, Ont.

TYPE J DESIGNS TO MEET WIDE DESIGN REQUIREMENTS

Standard Type J Relays. Twin contacts (Palladium standard). Rated current-carrying capacity: 4 amperes, 150 watts.

Power Type J Relays. Heavy-duty contacts riveted to springs. Code 18 (Silver). Rated current-carrying capacity: 10 amperes, 27½ volts d-c.

Type J Video Relays. For switching video and other high-frequency currents.

Write for Engineering Data Book and Bulletin 119

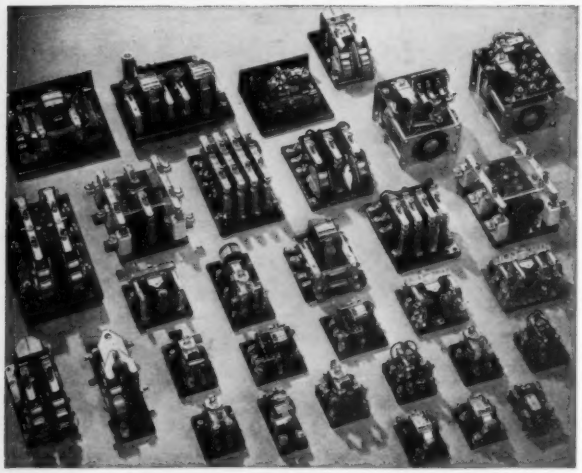
C. P. CLARE Canada Ltd.

Relays and related control components

For further information mark No. 26 on Readers' Service Card

RUGGED DEPENDABLE RELAYS by WARD LEONARD

- A comprehensive range
- For light, standard or heavy duty
- Always available from stock
- New, fully illustrated catalog just published



Relays can control complex switching operations more efficiently and more economically than any system of manual control. Machines, oil-burners, pumps, compressors — can be started, stopped or adjusted as required, and the switching can be triggered by changes in temperature, pressure, volume, voltage — automatically and reliably.

Ward Leonard relays have been proven on installations right across Canada. Past customers come to Ward Leonard time after time for each new application. Profit from their experience. When you want quality relays, for general or industrial purposes — call for **Ward Leonard** relays!

Write for your free illustrated catalogue — today!

WARD LEONARD OF CANADA LIMITED
1070 BIRCHMOUNT ROAD TORONTO 16

Resistors • Rheostats • Relays • Motor Controls • Dimmers • Loadbanks • SAFT Batteries • Barkelew Switches

For further information mark No. 63 on Readers' Service Card

There's a stronger, more compact ARROW-HART SWITCH CONTROL for every job!

Arrow-Hart offers a complete range of quick make and break switches for vacuum sweepers, fans, power tools, radio and electronic equipment.
Send for your copy of the new illustrated Bulletin Z-12 today . . . and ask us for any additional advice or information you may need.

ARROW-HART & HEGEMAN (CANADA) LIMITED

INDUSTRY STREET, TORONTO 15, ONTARIO
7365 MOUNTAIN SIGHTS, MONTREAL, QUE.
Quality MOTOR CONTROLS • WIRING DEVICES • APPLIANCE SWITCHES

6006-R

For further information mark No. 14 on Readers' Service Card

distributors and manufacturers for

E.M.I. ELECTRONICS LTD.
COSSOR INSTRUMENTS LTD.
COSSOR COMMUNICATIONS CO.
COSSOR RADAR & ELECTRONICS LTD.

E.M.I. COSSOR

ELECTRONICS LIMITED

Medical Colour T.V.
Closed Circuit T.V.
EMI. CATV Systems
*Oscilloscopes
Oscillators and Generators
Photo Electric Transducers
Machine Tool Control
Transistor Curve Traces
Vertical & Oblique Ionospheric Recorders
Audio frequency test equipment
Dynamic Balancing equipment
Instrumentation and Audio Amplifiers
Magnetic Recording Tapes, Video and Audio
Noise and Vibration Analyzing equipment
Automatic Conveyance Systems
Ultrasonic Cleaning equipment

Electronic measuring instruments for all phases of the electronics industry

E.M.I.—COSSOR ELECTRONICS LIMITED

HEAD OFFICE and PLANT:
P.O. Box 525, Woodside, Dartmouth, N.S., Halifax 466-7491
Sales Office: 2005 Mackay St., Montreal, P.Q., VI. 4-3801
Sales Office: 3077 Bathurst St., Toronto, Ont., RU. 1-2919
ALSO — 160 Laurier Ave. W., Ottawa, CE. 5-4306

For further information mark No. 33 on Readers' Service Card

WHITTAKER
Electronics Limited

head office
1171 Whitmore Ave.
Ottawa 3, Ontario
PA. 2-8563

Central Ontario Office
2 Neapolitan Drive
Scarboro, Ontario
AX. 3-3161

Quebec & Maritime Offices
5056 Chestnut Ave.
Pierrefonds, Montreal, Que.
MUrray 4-3000

Collect calls accepted

thumbnail sketch
OUR PRINCIPALS - THEIR PRODUCTS

COMPLETE DATA ON REQUEST

- **DRESSEN-BARNES DC** power supplies, modules & rack mtd., tube & transistorized types. Kits. *STOCKED AT OTTAWA & TORONTO.*
- **DYNAMIC GEAR CO. INC.** precision stock gears, differentials, slip clutches, gearheads, speed reducers, breadboards, custom gears.
- **GUDEBROD BROS. SILK CO. INC.** lacing tapes per MIL-T-713a in nylon, dacron, teflon, fiberglass. Dial cords. *STOCKED IN OTTAWA & TORONTO.*
- **HOPKINS ENG. CO.** subminiature paper & plastic film capacitors.
- **INTERNATIONAL INSTRUMENTS INC.** 1" & 1½" round, 1½" square, and edgewise indicating meters. Electronic Control Meters. *STOCKED IN OTTAWA & TORONTO.*
- **INDUSTRIAL ELECTRONIC ENGINEERS, INC.** one plane digital displays and related components. *STOCKED IN OTTAWA & TORONTO.*
- **PANORAMIC RADIO PRODUCTS INC.** spectrum analyzers from ½ cps - 44 kmcs.
- **SPECTROL ELECTRONICS CORP.** *& SPECTROL ELECTRONICS OF CANADA LIMITED* precision potentiometers, trimmer potentiometers, dials. *STOCKED BY US IN OTTAWA & TORONTO, BY PAYETTE RADIO LTD. IN MONTREAL, L. A. VARAH LTD. IN VANCOUVER. SPECTROL* potentiometers now *MADE IN CANADA.*
- **TELONIC INDUSTRIES INC.** sweep generators, attenuators, filters, etc.
- **WINCHESTER ELECTRONICS INC.** quality connectors, terminals, accessories.

For further information mark No. 65 on Readers' Service Card

WHEN WRITING TO ADVERTISERS TELL THEM YOU SAW IT IN

CANADIAN ELECTRONICS ENGINEERING

IS **MARKING - -**
- - A PROBLEM?

INDUSTRIAL, DIRECT AND TRANSFER PRINTING EQUIPMENT A SPECIALTY

LET CANADA'S FOREMOST MANUFACTURER OF MARKING EQUIPMENT ASSIST YOU.

BARNARD STAMP & STENCIL LIMITED
8 GEORGE ST. HAMILTON, ONTARIO

For further information mark No. 20 on Readers' Service Card

IT'S NEW!

SMG-57 Sweep Marker Generator

A combination sweep and marker generator — 1% accuracy. Continuous frequency Coverage—3 m.c. to 260 m.c. Vernier dial drive.
Internal crystal controlled 4.5 m.c. oscillator. This unusually accurate (1%) versatile unit can speed up difficult trouble shooting and alignment; over 100,000 Micro-Volt, variable output. Individually calibrated on marker frequency clearly showing exact setting for all key I.F. markers.

WIRED AND CALIBRATED ONLY **$139.95**

STARKIT

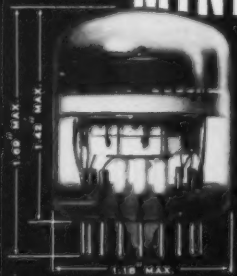
STARK ELECTRONIC INSTRUMENTS LTD.
AJAX, ONTARIO

For further information mark No. 58 on Readers' Service Card

NEW *from Baird-Atomic*

MINIATURIZED COUNTING TUBE

featuring routing guides for simplified bi-directional counting



DEKATRON® GS10H
- Maximum counting rate sine wave and rectangular pulses... 5,000 p.p.s.
- Maximum anode current ... 600 μA
- Maximum output at 5 kp/S with a 100 kΩ cathode load resistor and +50 V bias: 35 V
- Access to all ten cathodes

Incorporating a routing-guide system to provide glow direction sensing, this new cold cathode tube reduces the process of multi-stage, reversible, bi-directional counting and selecting to its simplest terms. This means fewer components, resulting in increased reliability and reduced costs. Ruggedly constructed, the GS10H follows the long Dekatron® tradition for reliability and performance.

WRITE FOR THE NEW B/A HANDBOOK OF COUNTING TUBES. PRICE: $1.00

B A **BAIRD-ATOMIC** of Canada, Ltd.
Suite 303, 465 Gilmour Street, Ottawa, Ontario

ADVANCED OPTICS AND ELECTRONICS . . . SERVING SCIENCE

For further information mark No. 18 on Readers' Service Card

1962 IN PARIS
PORTE DE VERSAILLES
FEBRUARY, 14-20.

5th international exhibition of electronic components

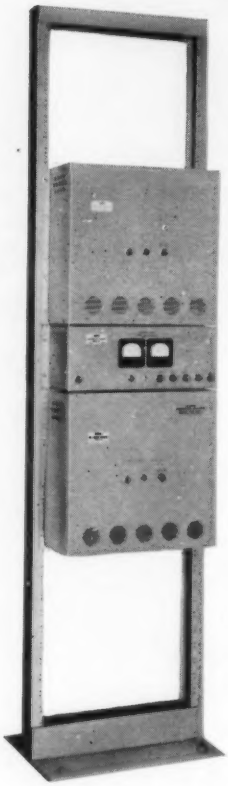
The greatest
World meeting
in the field
of electronics

FEDERATION FRANÇAISE
DES INDUSTRIES ELECTRONIQUES

23 RUE DE LÜBECK, PARIS 16e
PASSY 01.16

For further information mark No. 35 on Readers' Service Card

Roses are red . . .



. . . Violets are blue.

Why add a battery,

Where a PYLON will do?

Write for further details to:

PYLON

PYLON ELECTRONIC DEVELOPMENT company, ltd.
Communications Systems and Equipment
161 CLEMENT ST., LASALLE, MONTREAL 32, QUE.

For further information mark No. 51 on Readers' Service Card

SPECIFY **stevens - arnold DC-AC choppers**

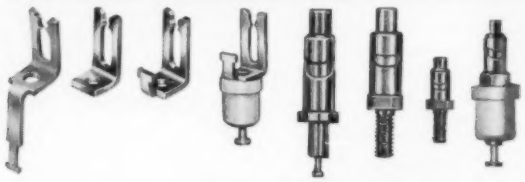
for **dependability**

Only Stevens-Arnold Choppers offer the consistently excellent performance of individually adjusted twin contacts. They are designed and constructed to meet the most stringent requirements in low level, low noise applications.

Get complete information . . .

FROM
JOHN HERRING & COMPANY LTD.
3468 DUNDAS STREET WEST
TORONTO, CANADA

For further information mark No. 59 on Readers' Service Card



Save Time and Trouble . . . with CAMBION® Component Clips

Here's why you can count on CAMBION component clips for fast, trouble-free installation in any application — in prototyping or production, conventional or printed circuits.

CAMBION designs more clips and produces more, offering you widest choice. Types include spring-loaded or spade . . . screw stud or rivet-mounted . . . Teflon*-insulated for press mount, or non-insulated. Brass housings plated with bright alloy, or gold if you wish. Clips have fatigue-tested stainless steel springs to assure extra long service life. Wire sizes handled range from .005" to .085". Use at temperatures to 200°C.

Simplify your assembly operations — from the start. Write *now* for details to Cambridge Thermionic Corporation of Canada, Ltd., 2425 Grand Blvd., Montreal 28, P.Q.

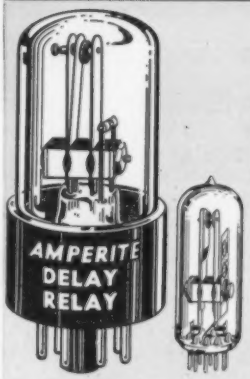
*Reg. Du Pont T.M.

CAMBRIDGE THERMIONIC CORPORATION
CAMBION®
The guaranteed electronic components

For further information mark No. 22 on Readers' Service Card

AMPERITE

THERMOSTATIC
DELAY RELAYS



2 to 180 Seconds

Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.

Hermetically sealed. Not affected by altitude, moisture, or climate changes.

SPST only—normally open or closed.

Compensated for ambient temperature changes from —55° to +70° C. Heaters consume approximately 2 W. and may be operated continuously. The units are **rugged, explosion-proof, long-lived, and—inexpensive!**

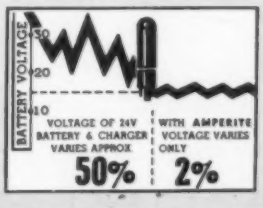
TYPES: Standard Radio Octal, and 9-Pin Miniature . . **List Price, $4.00.** Standard Delays

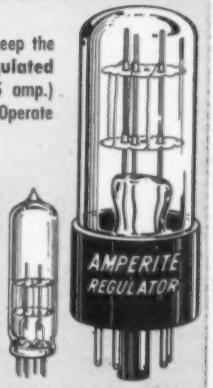
Also — **Amperite Differential Relays:** Used for automatic overload, under-voltage or under-current protection.

PROBLEM? Send for Bulletin No. TR-81

AMPERITE
BALLAST REGULATORS

Amperite Regulators are designed to keep the current in a circuit **automatically regulated** at a definite value (for example, 0.5 amp.) . . . For currents of 60 ma. to 5 amps. Operate on A.C., D.C., or Pulsating Current.





Hermetically sealed, they are not affected by changes in altitude, ambient temperature (—55° to +90° C.), or humidity . . . Rugged, light, compact, most inexpensive . . . . . **List Price, $3.00.**

Write for 4-page Technical Bulletin No. AB-51

AMPERITE
561 Broadway, New York 12, N. Y. . . . CAnal 6-1446
In Canada: Atlas Radio Corp., Ltd., 50 Wingold Ave., Toronto 10

For further information mark No. 11 on Readers' Service Card

Graham D. Clifford, general secretary of the British Institution of Radio Engineers, took time out from his official visit to the Montreal Section to present the 1959 Brabazon Award to four National Research Council engineers for their development of a crash position indicator. Left to right: R. R. Real, H. Ross Smyth, Mr. Clifford, Dr. D. M. Makow, S. K. Keays.

Canadian Electronic Sales Reps. expand association activities

The Canadian Electronic Sales Representatives Association, which formerly embraced only people selling to distributors, is expanding to include sales representatives who specialize in the industrial and original equipment field.

Among the projects of C.E.S.R. is interchange of information on average salaries to be paid to salesmen, how to handle expense accounts, and other useful data, particularly for new companies.

The association has made arrangements for a group accident insurance policy, and a group pension plan, with rates much lower than could be obtained by individual companies.

A social evening is planned for the near future. Members and prospective members are invited. Details may be obtained from R. C. Kahnert, chairman, C.E.S.R., 73 Crockford Blvd., Scarborough, Ont.

Project fosters effective teaching

The Ford Foundation is sponsoring a series of summer institutes for engineering teachers on effective teaching. Professor J. W. Brooks of the Civil Engineering Dept., Queen's University, attended the two-week course held at Pennsylvania State University in Sept. The course had three objectives: the training in fundamental principles and use of effective teaching methods; orientation of young teachers to their profession; encouragement of research in methods for improvement of learning.

Professor Brooks said a remarkable development at present is the number of teaching aids, teaching machines and programmed learning devices being developed for engineering teachers. These include closed circuit TV and teaching machines which effectively provide one instructor for each student.

Electrical engineers plan five-day program

A full five-day technical program that will blanket the entire electrical-electronics field is in the making for the first industry-wide gathering of its kind — the Winter General meeting of the American Institute of Electrical Engineers and the 1962 Electrical Engineering Exposition.

More than 800 research engineers have been invited to present technical papers at some 120 separate sessions that will be held January 29-February 2, 1962 in the New York Coliseum.

Exhibits will be based upon the research efforts of electrical-electronics engineers, arranged to augment the information provided in the technical sessions.

Papers wanted for packaging symposium

Technical papers for presentation at the Third Electronic Packaging Symposium are now being solicited by the University of Colorado. The 1962 meetings will take place on the campus in Boulder, Colorado, August 15-17.

General papers covering over-all electronic packaging concepts, as well as papers dealing with specific designs are desired. Areas covered may range from the microscopic to the macroscopic with emphasis on electronic packaging materials, packaging for outer space, packaging for appearance, underground and underwater packaging, interconnections in packaging, and packaging economics.

Titles of proposed papers, with a 500-word outline of subject matter, are all that is needed initially for preliminary screening. Send three copies to Alan Brown, 352 Chemistry Building, University of Colorado, Boulder, Colorado.

COMING EVENTS

December

13 Meeting of the Society for Experimental Stress Analysis, Toronto-Hamilton Section; Ontario Hydro Head Office, Toronto. Subject is Photostress Techniques.

Jan. 29-Feb. 2

Winter General Meeting of AIEE and the 1962 Electrical Engineering Exposition, New York Coliseum.

February

3-11 Pacific Electronics Trade Show, Shrine Auditorium, Los Angeles.

14-20 Fifth Electronic Components International Exhibition, Paris, France.

March

26-29 IRE International Convention, New York Coliseum & Waldorf Astoria Hotel, N.Y.

What's ahead for electronics?

The Canadian Electronics Industry appears to be climbing once more. Latest indications are that business has improved in most of the major segments of the industry.

Increased commercial export sales, defense production sharing, and the long-awaited "second TV set" sales have been some of the major factors in the upswing.

The January issue of CEE, which is the annual Review and Forecast issue, will provide latest statistics.

Free service for our readers

Keep your reference shelf up to date this easy way. All advertisements, new products and literature in this issue have a key number. For more information

- **Circle the key number on one of these cards**
- **Print your name, position, address and firm, then mail — postage is paid.**

Some advertisements cannot be numbered due to lack of space. Their key numbers are, however, given in the advertisers' index.

BUSINESS REPLY CARD
No postage necessary if mailed in Canada

POSTES CANADA POSTAGE 5 CENTS 15500

FIVE CENTS POSTAGE WILL BE PAID BY

CANADIAN ELECTRONICS ENGINEERING

481 University Avenue,

Toronto 2, Ontario

please send information on these items:

not valid after 6 months

December 1961

1	2	3	4	5	6	7	8	9	10	11	12	13	14	1
16	17	18	19	20	21	22	23	24	25	26	27	28	29	3
31	32	33	34	35	36	37	38	39	40	41	42	43	44	4
46	47	48	49	50	51	52	53	54	55	56	57	58	59	6
61	62	63	64	65	66	67	68	69	70	71	72	73	74	7
76	77	78	79	80	81	82	83	84	85	86	87	88	89	9
91	92	93	94	95	96	97	98	99	100	101	102	103	104	10
106	107	108	109	110	111	112	113	114	115	116	117	118	119	12
121	122	123	124	125	126	127	128	129	130	131	132	133	134	13
136	137	138	139	140	141	142	143	144	145	146	147	148	149	15
151	152	153	154	155	156	157	158	159	160	161	162	163	164	16
166	167	168	169	170	171	172	173	174	175	176	177	178	179	18
181	182	183	184	185	186	187	188	189	190	191	192	193	194	19
196	197	198	199	200	201	202	203	204	205	206	207	208	209	21
211	212	213	214	215	216	217	218	219	220	221	222	223	224	22

name _____
(PLEASE PRINT)

position _____

company _____

address _____

_____

SUBSCRIBE NOW! In Canada 1 year $5 ☐ 2 years $9 ☐ U.S. & U.K. $10, oth countries $20 a year (remit with order). Please initial .....

BUSINESS REPLY CARD
No postage necessary if mailed in Canada

POSTES CANADA POSTAGE 5 CENTS 15500

FIVE CENTS POSTAGE WILL BE PAID BY

CANADIAN ELECTRONICS ENGINEERING

481 University Avenue,

Toronto 2, Ontario

please send information on these items:

not valid after 6 months

December 1961

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165
166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195
196	197	198	199	200	201	202	203	204	205	206	207	208	209	210
211	212	213	214	215	216	217	218	219	220	221	222	223	224	225

name_____
(PLEASE PRINT)

position_____

company_____

address_____

_____

SUBSCRIBE NOW! In Canada 1 year $5 ☐ 2 years $9 ☐ U.S. & U.K. $10, other countries $20 a year (remit with order). Please initial .....

BUSINESS REPLY CARD
No postage necessary if mailed in Canada

POSTES CANADA POSTAGE 5 CENTS 15500

FIVE CENTS POSTAGE WILL BE PAID BY

CANADIAN ELECTRONICS ENGINEERING

481 University Avenue,

Toronto 2, Ontario

please send information on these items:

not valid after 6 months

December 1961

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165
166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195
196	197	198	199	200	201	202	203	204	205	206	207	208	209	210
211	212	213	214	215	216	217	218	219	220	221	222	223	224	225

name_____
(PLEASE PRINT)

position_____

company_____

address_____

_____

SUBSCRIBE NOW! In Canada 1 year $5 ☐ 2 years $9 ☐ U.S. & U.K. $10, other countries $20 a year (remit with order). Please initial .....

Advertisers' Index

Key No.		Page No.
11	Amperite Company	77
12	Ampex of Canada Ltd.	20
	Amphenol Canada Ltd.	23
13	Andrew Antenna Corp. Ltd.	28
14	Arrow, Hart & Hegeman (Canada) Ltd.	74
15	Automatic Electric Sales (Canada) Ltd.	16
16	Automatic Electric Sales (Canada) Ltd.	34
17	Bach-Simpson Ltd.	24
18	Baird-Atomic of Canada Ltd.	75
19	Ballantine Labs. Inc.	61
20	Barnard Stamp & Stencil Ltd.	
21	Boston Insulated Wire & Cable Co. Ltd	72
	Business Newspapers Association of Canada	62
22	Cambridge Thermionic of Canada Ltd.	77
23	Canada Wire & Cable Co. Ltd.	21
24	Canadian Westinghouse Company Ltd., (Electronics Div.)	26
25	Chicago Dynamic Inc.	73
26	Clare Canada Ltd., C. P.	73
27	Dale Electronics, Canada, Ltd.	64
28	Daystrom Limited	32
29	Du Pont of Canada Ltd.	25
30	Edo (Canada) Ltd.	63
31	Eitel McCullough Inc.	OBC
32	Emcor, Ingersoll Products Div. (Borg-Warner Corp.)	66
33	E M I Cossor Electronics Ltd.	74
34	Electrosonic Supply Co.	72
35	Federation Française Des Industries Electroniques	76
36	General Instrument Ltd., Semiconductor Div.	2
37	General Radio Co.	4
38	Hewlett-Packard Company	31
39	Hewlett-Packard Company	IBC
40	Honeywell Controls Ltd.	29
41	Lenkurt Electric Co. Ltd.	17
42	Litton Systems (Canada) Ltd.	8
43	Microwave Associates, Inc.	6
44	Milgray Electronics	70
45	Northern Electric Co. Ltd.	10
46	Northern Electric Co. Ltd.	33
47	Payette Radio Limited	65
48	Philco Corp. of Canada Ltd.	12-13
49	Philips Electronics Industries Ltd.	14-15
50	Potter & Brumfield, Div. of AMF Canada Ltd.	19
51	Pylon Electronic Development Co. Ltd.	76
52	Railway & Power Engineering Corp. Ltd.	30
53	Rider Publisher Inc., J. F.	71
54	Sanborn Company	22
66	Sharp Instruments of Canada Ltd., E. J.	61
55	Sinclair Radio Laboratories Ltd.	69
56	Smalley's Radio Ltd.	69
57	Southco Division, South Chester Corp.	18
58	Stark Electronic Instruments Ltd.	75
59	Stevens Arnold Inc.	77
60	Tech Laboratories Inc.	71
61	Tung-Sol Electric, Inc.	27
62	Varian Associates of Canada Ltd.	IFC
63	Ward Leonard of Canada Ltd.	74
64	Welwyn Canada Ltd.	68
65	Whittaker Electronics Limited	75

PRESENTING HEWLETT PACKARD (CANADA) LTD.

With pride, Hewlett-Packard announces the establishment of Hewlett-Packard (Canada) Ltd. as of January 1, 1962. The continued growth of the Canadian electronics industry, plus the increasing usage of *hp* instruments in Canada, has dictated this move.

Hewlett-Packard (Canada) Ltd. is staffed by Canadian electronic sales engineers, trained for over a year at Hewlett-Packard's home laboratories and plants. Their objective is to give you maximum assistance on the application, procurement and servicing of *hp* test instruments. Headquarters are in Montreal, with branch offices in Toronto and Ottawa and an instrument repair station in Montreal. Orders or inquiries concerning new purchases of *hp* equipment should be addressed to your nearest Hewlett-Packard (Canada) Ltd. office after January 1, 1962.

For your convenience, here are the new Hewlett-Packard (Canada) Ltd. offices:

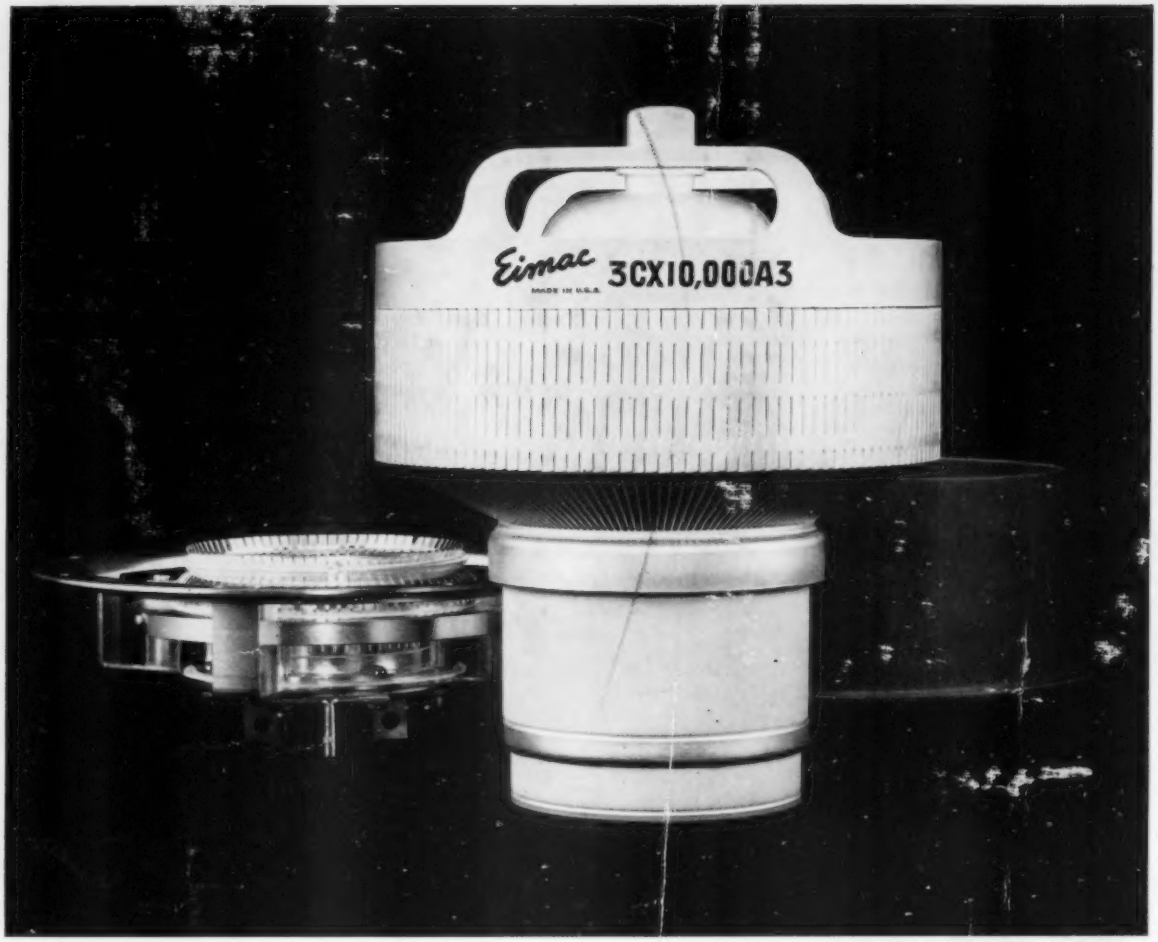
Montreal: 8270 Mayrand Street, telephone 735-2273
Toronto: 1415 Lawrence Ave. W., telephone 249-9196
Ottawa: 1762 Carling Ave., telephone PArkway 2-8162

hp is achievement in measurement

HEWLETT PACKARD COMPANY

1097L Page Mill Road Palo Alto, California, U. S. A.
DAvenport 6-7000
Field representatives in all principal areas

For further information mark No. 38 on Readers' Service Card



UNIQUE NEW EIMAC 3CX10,000A3 CERAMIC TRIODE OFFERS VHF POWER–UP TO 20 KW

Eimac expands its ceramic tube line with the introduction of the 3CX10,000A3 – the only 10 kilowatt air-cooled ceramic triode in the field. This advanced power tube is intended for use at maximum ratings through 110 megacycles.

An outstanding feature of this clean, efficient ceramic triode is the large reserve of grid dissipation assured by platinum-clad tungsten grid wires. Overload protection has also been built into the 3CX10,000A3 to make it ideal for use in industrial heating – dielectric and induction.

This newly developed triode is also well suited for such applications as broadcast, FM and single-sideband transmitters, ultrasonic generators and sonar pulse amplifiers. It can also be used as a class-AB_2 or class-B linear amplifier in audio or r-f service.

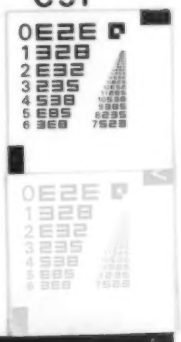
A companion air-system socket and chimney, as shown above, is available with the 3CX10,000A3 to meet your specific requirements. Watch for a low mu version of this high-power triode in the near future.

GENERAL CHARACTERISTICS EIMAC 3CX10,000A3	Height	Diameter	Max. Operating Temp.	Filament Voltage	Filament Current	Frequency for Max. Ratings	Max. Plate-Diss. Rating
CERAMIC TRIODE	8.50"	7.0"	250°C.	7.5	100 amps	110 Mc.	10,000 watts

EITEL-McCULLOUGH, INC.
San Carlos, California

Canadian Representative: R. D. B. SHEPPARD,
901 Rob Roy Ave., Ottawa 3, Ontario, Canada.

60092

For further information mark No. 31 on Readers' Service Card

C51